Universitat Autònoma de Barcelona

Personal Biosecurity Measures Followed by Ruminant Veterinarians and Farmers in the Country of Georgia

Master's Degree Thesis in Zoonoses and One Health

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ABSTRACT

Background: Zoonotic diseases pose a major economic and public health threat globally. Georgia, located in the Caucasus region, is particularly impacted by such diseases as brucellosis, anthrax, Crimean-Congo haemorrhagic fever, tuberculosis, and echinococcosis. By practicing personal biosecurity measures, such as proper hand washing and using personal protective equipment (PPE), exposure to pathogens can be minimized.

Objective: To evaluate the extent to which veterinarians and farmers working with ruminants across Georgia have adopted personal biosecurity measures.

Methodology: A cross-sectional study was conducted in July-September 2024 by using questionnaires administered to ruminant farmers and veterinarians across the country.

Results: 433 farmers and 114 veterinarians interviewed either face-to-face or online. 41.8% of farmers did not believe that it was possible to contract a disease from their animals, but surprisingly they tended to score higher in implementing many personal biosecurity measures. 70.2% of veterinarians perceived themselves as having a high level of knowledge about zoonoses; however, only four veterinarians correctly identified zoonotic diseases from the given list. Proper hand washing, milk boiling, safe carcass disposal, and cleaning and disinfection practices; as well as PPE usage while working with animals in different situations were applied by most respondents. Among farmers, being female, having a higher educational level and engaging in discussions with experts on PPE and zoonoses were linked to better adherence to personal biosecurity measures. Likewise, high level of perceived knowledge regarding zoonoses and working as a field veterinarian were related to better PPE usage scores. In contrast, greater experience in livestock care among farmers and working fewer than three days per week among veterinarians were associated with lower adherence to these measures.

Conclusions: Through this research, we have provided a comprehensive understanding of personal biosecurity practices across Georgia and believed to have contributed to raising awareness about zoonotic diseases and their prevention in the country. Despite the widespread adoption of personal biosecurity practices among farmers and veterinarians; the insufficient use of face masks and protective glasses in high-risk situations such as managing aborted materials, combined with the belief among some farmers that animals cannot transmit diseases and the gaps in knowledge about zoonoses require further attention.

Keywords; biosecurity, farmers, Georgia, personal protective equipment, ruminants, veterinarians, zoonoses

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bTB	: Bovine Tuberculosis
CCHF	: Crimean-Congo Haemorrhagic Fever
FAO	: Food and Agriculture Organization of the United Nations
LMA	: Laboratory of Ministry of Agriculture
NCDC	: National Centre for Disease Control and Public Health
NFA	: National Food Agency
PPE	: Personal Protective Equipment
TB	: Tuberculosis
UNEP	: United Nations Environment Programme
WHO	: World Health Organization
WOAH	: World Organization for Animal Health

1. INTRODUCTION

1.1. Defining biosecurity

The concept of biosecurity is defined diversely across different sectors and disciplines due to its broad application and significance in safeguarding against the spread of infectious agents and ensuring the health and safety of animals, humans, plants, and the environment.[1] Historically, biosecurity has been primarily understood in terms of internal and external measures.[2] In consistent with this initial concept, the World Organization for Animal Health (WOAH) defines biosecurity as 'a set of management and physical measures designed to reduce the risk of introduction, establishment, and spread of animal diseases, infections, or infestations to, from, and within an animal population.'[3] In the traditional notion; external biosecurity focuses on preventing pathogens from entering a farm or herd through implementing measures such as physical barriers, quarantine procedures, visitor protocols, and the sanitation of vehicles and equipment; internal biosecurity aims to reduce the spread of pathogens within a herd once they are present and includes measures such as isolating and segregating sick animals, cleaning and disinfection, managing feed and water sources or working routines.[4,5] Nonetheless, this original definition of biosecurity did not encompass broader aspects, such as the prevention of zoonotic diseases in humans or the environmental impact (e.g., biocide use). Recent opinion and review papers proposed a broader concept of biosecurity that integrated human, animal, plant, and environmental health.[6,7] This latest definition, which was considered as the most optimal definition of livestock biosecurity in a recent survey conducted among the scientific community,[8] conceptualized the rules of 5Bs and included the following five compartments:[9,10]

- Bio-exclusion: This involves implementing biosecurity measures to prevent the introduction of pathogens onto the farm. Examples include screening procedures for new animals, limiting farm access to authorized personnel, and disinfection protocols for equipment, vehicles, and visitors.
- Bio-compartmentation: These measures aim to prevent the spread of pathogens within the farm. This includes practices such as segregating animals based on health status, implementing strict hygiene protocols, and maintaining clean and sanitized facilities.
- Bio-containment: This compartment focuses on preventing the spread of pathogens to other farms or premises. Measures may include safe carcass disposal, and restricting the movement of animals, equipment, and personnel from the farm.

- Bio-prevention: These measures target the prevention of zoonotic pathogens from spreading to humans. This involves implementing practices such as personal protective equipment (PPE) for all stakeholders (farmers, veterinarians, salesmen, truck drivers etc), vaccination programs for both animals and humans where applicable, and proper hygiene practices to minimize the risk of disease transmission from animals to humans.
- Bio-preservation: Bio-preservation measures aim to prevent environmental contamination from farm activities. This includes proper management of manure, waste disposal, and other organic material, minimizing run-off and pollution, and implementing practices to protect natural habitats and ecosystems surrounding the farm.

Each biosecurity measure can be associated with one or more of these compartments, highlighting their multifaceted role in protecting animal and public health as well as environmental integrity. Effective biosecurity practices require a combination of measures tailored to the specific risks and challenges faced by each farm or production system.

1.2. Zoonotic disease burden in Central Asia and the Caucasus

Living in proximity, humans and animals share a mutually dependent relationship globally. However, this closeness also poses risks, as a wide array of agents can transfer from animals to humans, potentially causing infections. In fact, of the 1.415 agents responsible for human diseases, 61% are zoonotic. Additionally, 75% of the 175 defined emerging infections are zoonotic and zoonotic pathogens are twice as likely to be associated with emerging diseases than non-zoonotic pathogens.[11,12]

The interconnectedness between people, animals, and the environment has led to a scenario where the well-being of animals is closely intertwined with that of humans. The concept of 'One Health' recognizes the significant potential to safeguard public health by implementing policies that focus on preventing and managing zoonotic diseases and emerging illnesses at the intersection of human, animal, and environmental interactions. The Quadripartite Organizations -comprising the Food and Agriculture Organization of the United Nations (FAO), the United Nations Environment Programme (UNEP), the World Organisation for Animal Health (WOAH), and the World Health Organization (WHO)- work together to spearhead the necessary change and adaptation to alleviate the effects of present and future health threats; operating at global, regional, and national levels.[13]

Putting One Health initiative into practice, the WHO and WOAH have identified three priority diseases -brucellosis, echinococcosis, and rabies- of critical significance for both

human and animal well-being in Central Asia and Caucasus countries. These diseases are prevalent globally, posing substantial economic and public health burdens, and stand to gain from collaborative efforts across multiple sectors.[14] As one of the countries situated in the Caucasus region, Georgia established a National Animal Health Programme Steering Group in 2013 to facilitate intersectoral consultation for the control of zoonotic diseases. This collaborative effort forms a One Health team consisting of the National Food Agency (NFA), the Laboratory of Ministry of Agriculture (LMA), National Centre for Disease Control and Public Health (NCDC), as well as other stakeholders and donors. This group has developed a list of zoonotic diseases of greatest public health concern including brucellosis, anthrax, rabies, avian influenza, Crimean-Congo haemorrhagic fever (CCHF), poxvirus infections, diseases caused by typhus group Rickettsiae, Q fever, haemorrhagic fever with renal syndrome, tularaemia, and plague. A vaccination program has been enacted for animals to combat brucellosis, anthrax, and rabies. Additionally, a vaccination initiative is in place for high-risk human groups, such as hunters and veterinarians, for rabies exposure.[15]

Zoonotic infectious diseases pose a significant economic burden on countries worldwide due to various factors. Treating zoonotic infections in humans requires medical attention, medication, and sometimes hospitalization. These costs can quickly escalate, especially in cases where outbreaks occur, and large numbers of individuals require treatment simultaneously. Zoonotic diseases can also affect livestock and agricultural production. Outbreaks in animals can lead to loss of livestock, decreased production, and trade restrictions on animal products, resulting in economic losses for farmers and the food industry. Countries affected by zoonotic disease outbreaks may experience a decline in tourism and trade as other countries implement travel restrictions and trade bans to prevent the spread of the disease. These can have significant economic ramifications, particularly for countries heavily reliant on tourism and exports. Investing in biosecurity measures may prevent these losses, as it is considered a cost-effective method of infection prevention.[16]

1.3. Occupational health risks for veterinarians and farmers

Veterinarians and farmers are crucial to the agricultural and animal husbandry sectors, but their work exposes them to numerous health risks. Exposure to zoonotic diseases is one of these risks worldwide and veterinarians and farmers are particularly susceptible due to their frequent and direct contact with animals.

Anthrax is a disease widely recognized for its potential to be transmitted from animals to humans and Georgia, a country located at the crossroads of western Asia and eastern Europe,

lies in a region where anthrax is endemic. Effective control of anthrax begins with managing the disease in livestock, primarily through vaccination programs. In the country, annual livestock vaccination was traditionally managed by official programs. However, in 2007, this responsibility shifted to livestock owners, and hiring private veterinarians became optional. By 2013, human anthrax outbreaks linked to livestock handling had increased fivefold.[17] An epidemiological investigation conducted in 2012 revealed a strong correlation between human anthrax cases and several activities such as disposing of dead livestock, participating in livestock slaughter, caring for sick livestock, and handling livestock products.[18,19] Furthermore, a study done based on national surveillance data highlighted animal migration corridors (Kakheti near the border with Azerbaijan, through Kvemo-Kartli near Armenia and Türkiye) and living proximity to pastoralist routes as risk factors for human anthrax cases.[20] It was speculated that this spike in anthrax cases among both livestock and humans was due to decreased vaccination coverage, likely a result of the cost burden placed on livestock owners.[17,20]

In Georgia, brucellosis is one of the most prevalent bacterial zoonoses affecting livestock, leading to substantial economic losses due to infertility among livestock, reduced milk production, and higher calf mortality rates. Historically, the regions of Kakheti, Kvemo-Kartli, and Imereti have been designated as areas of concern for ruminant brucellosis.[21] A study examining the changing pattern of human brucellosis over three decades in these regions revealed that shepherds were the most affected occupation, followed by farmers.[22] Additionally, the epidemiological and clinical characteristics of brucellosis have been strongly linked to specific dietary habits, such as consuming unpasteurized milk and undercooked meat, as well as work-related practices like handling sick or aborted livestock, skinning animals, slaughtering cattle, and assisting with the delivery of cattle or small ruminants.[23]

The Crimean-Congo haemorrhagic fever virus is responsible for severe viral haemorrhagic fever outbreaks, with a case fatality rate of up to 40%. The disease is endemic in Africa, the Balkans, the Middle East, and Asian countries south of the 50th parallel north, which marks the geographical limit of the primary tick vector. Humans can contract the CCHF virus either through tick bites or by encountering infected animal blood or tissues during and immediately after slaughter. Most cases have been reported among individuals involved in the livestock industry, such as agricultural workers, slaughterhouse workers, and veterinarians.[24] In 2014, the highest seroprevalence (3%) of CCHF was recorded in twelve villages in southern Georgia since surveillance began in 2009. High-risk activities were identified as animal husbandry, herding, tick exposure, butchering raw meat, slaughtering, assisting in animal

births, drinking unpasteurized milk, working in healthcare settings, and participating in agriculture.[25]

Rabies is a neglected tropical disease with a high case fatality rate, causing an estimated 60,000 human fatalities annually, mostly among children in Africa and Asia.[26] The Caucasus region, near Europe's borders with the Middle East and west Asia, is close to areas where rabies remains endemic.[27] In Georgia, dog rabies is endemic and poses a serious public health threat. Although the government implemented a rabies control and mass vaccination program in 2013-2014, which reduced rabies incidence in owned dogs, the disease re-emerged among stray dogs, livestock, and wild animals.[28] In 2016, a rabies infected jackal was detected in Tbilisi, the capital. While no human rabies cases were reported between 2015 and 2017, three people died from rabies in 2018 and 2019.[29] In rabies endemic countries, cattle are the second most affected species after dogs.[30] Molecular analysis of rabies virus isolates in Georgia has shown a risk of dog-to-cattle transmission.[31] Due to its impact on livestock, rabies poses a potential risk to humans and has a growing impact on both the local and national economy.[26]

Human echinococcosis is a zoonotic disease caused by tapeworms of the genus *Echinococcus*. Infection in humans occurs through the ingestion of parasite eggs found in contaminated food, water, or soil, or through direct contact with animal hosts. Various herbivorous and omnivorous animals serve as intermediate hosts for echinococcus and the highest prevalence of the disease is observed in rural areas where older animals are slaughtered. *Echinococcus* infected livestock can suffer production losses due to liver condemnation, reduced carcass weight, lower hide value, decreased milk production, and diminished fertility. Besides, treating echinococcosis in humans is often costly and complex, frequently necessitating extensive surgery and/or prolonged drug therapy. For cystic echinococcosis, the post operative death rate for surgical patients averages 2.2%.[32] It has been revealed that echinococcosis is endemic in central and western Asia and the Caucasus,[33] however, no studies conducted in Georgia have been found.

Zoonotic tuberculosis (TB) is a form of TB in humans predominantly caused by the bacterial species *Mycobacterium bovis* and *Mycobacterium caprae* which is primarily adapted to cattle, where it is known as bovine TB (bTB). Transmission of bTB to humans occurs in two main ways: directly, through inhalation of the bacteria when in close contact with infected cattle or their carcasses, and indirectly, by consuming unpasteurized dairy products or raw meat from infected cattle. Populations that are at heightened risk of contracting zoonotic TB include livestock farmers, abattoir workers, veterinary personnel and hunters.[34] The true incidence of zoonotic TB is uncertain due to the lack of routine surveillance data, underreporting and

diagnosis challenges in many countries. Most low- and middle- income countries where bTB is endemic do not have estimates of its burden.[35] In Georgia, a nationwide study was conducted in 2016 - 2018 to assess the regional distribution of bTB in slaughtered cattle. The study found that only three regions (Kvemo-Kartli, Shida-Kartli, and Javakheti) had bTB, with an estimated prevalence of 0.44%.[36] Economic losses from bovine TB profoundly impact livelihoods of farmers, particularly in poor and marginalized communities by causing livestock deaths, chronic disease, productivity losses, and trade restrictions both locally and internationally.[35]

Parapoxviral infections characterized by skin lesions such as orf, bovine papular stomatitis, and pseudo-cowpox are frequent zoonotic diseases among animal health care professionals and farm workers. Humans contract poxvirus infections often through direct contact with skin lesions on infected animals. The disease typically presents as mild and self-limiting clinical course; however, nonspecific skin manifestations may be misdiagnosed as cutaneous anthrax or cowpox. Since 2014, substantial improvements in Georgia's epidemiological and laboratory capabilities have enabled surveillance and detection of parapoxviruses, facilitating estimation of the disease burden.[37,38]

The field of veterinary medicine, intrinsically linked to the One Health concept, serves as a crucial interface between human and animal health. Veterinarians, along with their staff, often stand at the forefront of encountering potentially infectious animals, exposing them to various zoonotic infections. Consequently, they play a pivotal role not only in diagnosing and treating animal diseases but also in identifying emerging infections and implementing measures to contain them before they pose significant threats to human communities. Veterinarians either mitigate the spread of infectious agents to humans, acting as the primary line of defence or inadvertently, without effective implementation of preventive measures, become vectors for zoonotic pathogens, potentially transmitting these infections to their colleagues, families, or other animals.[39,40]

1.4. Preventing zoonoses at the human-animal-environment interface

In recent years, there has been a notable transition from curative to preventive medicine. This shift has been underscored by the emergence of the biosecurity concept, which has become a fundamental component of both public and animal health.[7] Preventive measures stand as the cornerstone in averting many zoonotic infections safeguarding the well-being of both veterinary professionals and the broader community. Yet, there exists a pressing need for heightened attention to adherence to infection prevention and control practices within the veterinary field.[41] While it is not feasible to eliminate all such risks entirely, personal

biosecurity measures can be implemented to minimize exposure to known pathogens, thereby preventing widespread transmission.

1.4.1. Hand hygiene

Hand hygiene is a highly relevant measure in preventing the spread of pathogens, which includes hand washing with soap and water and the use of alcohol-based hand rubs. Washing hands with soap and running water effectively removes organic matter and decreases the presence of organisms on the skin. To minimize the risk of cross-contamination, it is advisable to use liquid or foam soap instead of bar soap. Alcohol-based hand rubs are suitable for use on clean hands without visible contamination. They work by denaturing microbial proteins, effectively decontaminating the hands. When used correctly, they provide strong protection against bacteria and enveloped viruses. However, their effectiveness is limited against certain non-enveloped viruses, spores, and protozoal parasites. Maintaining hand care is crucial as intact skin serves as a natural barrier against infections. It is important to cover cuts and abrasions with waterproof bandages during daily farm work. [42,43]

1.4.2. Personal protective equipment

Personal protective equipment serves as a fundamental measure in infection control protocols. When adhering to standard precautions, PPE usage aims to minimize the likelihood of contaminating personal clothing, skin, and mucous membranes and mitigate the transmission of pathogens among patients by veterinary or farm personnel.

Protective outerwear (lab coats, gowns, scrubs, overalls): Protective outerwear is crucial in minimizing the transmission of pathogens to patients, owners, veterinary staff, and the public. In addition to veterinarians, farmers assisting in situations involving infection risks should also wear protective clothing. It is important to promptly change these garments when visibly soiled or contaminated with bodily substances, and at the conclusion of each day. When visiting farms, overalls should be changed between properties to prevent cross-contamination.

Gloves or sleeves: Gloves play an essential role in minimizing the transmission of pathogens by providing a protective barrier. They should be worn when encountering an animal's blood, bodily fluids, mucous membranes, or compromised skin. Additionally, gloves are necessary when handling used instruments and equipment, managing clinical waste, cleaning stables and surfaces, and during laundry tasks. It is important to change gloves between examinations of individual animals or animal groups, between dirty and clean procedures performed on a single patient, and whenever they become torn. After glove

removal, hands should be washed thoroughly with soap and water or an alcohol-based hand sanitizer should be used.

Face protection (Surgical mask, goggles): Face protection is vitally important in preventing the exposure of mucous membranes in the eyes, nose, and mouth to infectious materials. This typically involves wearing a nose-and-mouth mask, such as a surgical mask or particulate respirators, along with goggles. It is crucial to utilize respiratory and eye protection whenever there is a risk of exposure to splashes or sprays.

Footwear (shoe covers, rubber boots): Appropriate footwear is necessary, designed to meet the specific demands of the working environment, offering protection against both physical injuries and exposure to infectious substances. During field visits, it is advisable to wear washable rubber boots, ensuring easy cleaning afterward. Before leaving any property, visible soil on footwear should be thoroughly removed using a scrubbing brush and water. [42,43]

1.4.3. Protective measures during veterinary procedures

Obstetrics: Zoonotic agents such as *Brucella spp, C. burnetii, and Listeria monocytogenes* are often present in high concentrations in the birthing fluids of animals undergoing abortion or giving birth, as well as in stillborn foetuses. To prevent exposure to these potentially infectious materials, it is essential to use gloves, sleeves, facial protection, and impermeable protective outerwear as necessary.

Necropsy: Performing necropsies carries a significant risk due to the potential exposure to infectious bodily substances, aerosols, and contaminated sharp objects. All individuals present during necropsies must wear gloves, masks, face shields or goggles, and impermeable protective outerwear as required. Additionally, veterinarians should utilize cut-resistant gloves to reduce the risk of sharp injuries. When using band saws or other power equipment, and in situations where airborne infection risks are present, respiratory protection such as N95 respirators should be utilized.

Diagnostic specimen handling: Faeces, urine, vomit, aspirates, and swabs should be treated as potentially containing infectious organisms. Protective outerwear and disposable gloves should be worn when handling these specimens. Consumption of food and beverages must be strictly prohibited in the laboratory. It is important to ensure that specimens for laboratory submission are securely sealed and handled hygienically to prevent exposure of laboratory, postal, or courier personnel to potential infectious agents.[42,43]

1.4.4. Cleaning and disinfection

Cleaning and disinfection are crucial for maintaining sanitation in animal areas, including any items that come into contact with animals, such as bedding material, milking equipment, hoof trimmers, gates and fences, feeding and watering systems, as well as equipment used for care, handling, or transport of animals or carcasses. All buildings, pens, and enclosures where animals are housed should be cleaned and disinfected, with special attention given to removing all manure from dirty floors. Equipment, particularly those used with ill animals, must be thoroughly cleaned and disinfected. Vehicles used for transporting animals, like trailers, should be cleaned and disinfected between uses and before leaving the operation. [42,43]

1.4.5. Management of laundry

When handling soiled laundry, it is important to wear gloves and protective outerwear. Bedding and other items should be washed in a washing machine with standard detergent and dried at the highest suitable temperature. To prevent cross-contamination, separate storage and transport bins for clean and dirty laundry should be used. Dedicated protective outerwear should be washed at the end of each day or whenever it becomes visibly soiled. If soiled laundry is washed at home, it should be transported in a sealed plastic bag and washed separately from other laundry. [42,43]

1.4.6. Sharps safety

Needlestick injuries occur frequently and carry significant risks, often leading to the accidental injection of live vaccines or exposure to infectious materials. When injecting live vaccines or aspirating body substances or tissue, the used syringe with the needle attached should be placed in a sharps container. To safely dispose of needles, it is recommended to use a designated sharps container equipped with a needle removal device. This device facilitates the safe separation of the needle from the syringe, allowing it to drop directly into the container. Under no circumstances should needle caps be removed using one's mouth. Recapping needles should only be done, when necessary, as it poses a significant risk of accidental needlestick injuries. [42,43]

1.5. Objectives

The main objective of this study is to assess the adoption of personal biosecurity measures among veterinarians and farmers working with ruminants throughout Georgia. Additionally, the study investigates their perceived risk of zoonotic transmission and factors affecting PPE usage.

METHODOLOGY

This cross-sectional questionnaire-based study is part of the larger initiative titled 'EUCENT Regional Disease Burden and Security Landscape Analysis,' led by the Food and Agriculture Organization of the United Nations in collaboration with the Autonomous University of Barcelona. The overarching objective of the project is to enhance the management of transboundary animal diseases and ruminant zoonoses in the Eurasian region.

1.5. Study area

This study was conducted in Georgia, a country situated in the Caucasus region along the Black Sea coast. Once part of the Soviet Union, Georgia is often considered a transcontinental country due to its location bridging eastern Europe and west Asia. It shares borders with Russia to the north and northeast, Türkiye and Armenia to the south, and Azerbaijan to the southeast. Despite its relatively small size, Georgia boasts remarkable mountainous terrain, primarily in the Caucasus Mountains. The country is administratively divided into nine regions, along with the capital region of Tbilisi, two autonomous republics, and 76 municipalities.[44] Its total population is 3.760.365, with 39% residing in rural areas.[45] The National Animal Identification and Traceability system has been in place since 2022. At the time of the study, Georgia had a population of 2.455.408 large ruminants and 600.269 small ruminants. Approximately 150.000 farmers and 1.000 veterinarians (comprising 500 field veterinarians and 500 official veterinarians) were involved in working with ruminants. Smallholder farms accounted for over 95% of all farms across the country, with only 5% categorized as commercial farms.[46] There were three main production types including mix breed extensive cattle, dairy cattle, and extensive sheep farming.

2.2. Development of questionnaires and leaflets

The study questionnaires for both farmers and veterinarians were collaboratively developed by researchers from Universitat Autònoma de Barcelona, along with experts from FAO Regional Office for Europe and Central Asia and FAO Georgia offices. Through a thorough examination of published literature and online guidelines, initial drafts of the questionnaires were created. Subsequent enhancements were made through interactive online meetings and feedback sessions involving stakeholders. After finalizing the questionnaires in English, the service provider (Applied Research Company), under the supervision of the FAO Georgia focal point, translated them into Georgian, Armenian, and Azerbaijani. The questionnaires were then adapted for the web survey software KoboCollect v2024.1.3. Necessary changes were made

following discussions between the research team, field supervisors, and interviewers. Subsequently, a pilot study was conducted with four farmers and three veterinarians, and no further changes were required after piloting (supp. file 1).

In addition to the questionnaires, informative leaflets were created for veterinarians and farmers using the same above-mentioned method, with additional contributions from WHO experts. These leaflets, available in English and Georgian, provided information on preventing zoonoses and adopting of personal protective equipment on the farm (supp. file 2).

2.3. Field-work

Face-to-face interviews were conducted with farmers and field veterinarians, primarily in rural settlements, by trained personnel in 53 municipalities of the country of Georgia in July 2024. To ensure consistency throughout the data collection process, field personnel received detailed instructions on the proper application of the questionnaire to obtain the most reliable responses. Consent forms were obtained before initiation of the questionnaire and upon completing the questionnaire, farmers and veterinarians were given leaflets with information on how to protect themselves from zoonoses. Data from official veterinarians were collected online. A questionnaire link, combined with a consent form and an informational leaflet, was emailed to recipients through the NFA mailing list. Three reminders were sent to participants between July and September 2024.

2.4. Sampling calculations

For farmers, a sample size of 387 was computed with a 95% confidence interval (corresponding to a Z-value of 1.96), 5% precision, and an expected level of implementation of personal biosecurity measures of 50%. Similarly, for veterinarians, the sample size was determined to be 100 for each group of field and official veterinarians based on calculation assuming a 95% confidence interval, a Z-value of 1.96 but a 10% precision, with an expected 50% implementation of personal biosecurity measures. Cochran's formula[47] was applied, which is adequate for situations where the population size is either large or unknown.

$$Cochran's\ formula$$

$$n = \frac{\mathrm{Z}^2 * \mathrm{p}\ (1 - \mathrm{p})}{\beta^2}$$

n = sample size

Z = corresponding value for predefined confidence interval

p = expected prevalence

β = precision

2.5. Recruitment of farmers

The country of Georgia is divided into 12 administrative regions and study holdings were selected proportional to the number of animals within each municipality across the different regions of Georgia. Considering that in Georgia there are on average three cattle or 100 sheep per holding (Personal communication, Dragan Angelovski), around 130.000 cattle holdings and 12.000 small ruminant holdings were estimated to be in the country. Therefore, at least 350 farmers engaged in a mix breed extensive cattle or dairy cattle farming, and 37 farmers involved in extensive sheep farming were targeted to be included in the study (Figure 1&2). Additionally, to mitigate the possibility of interviewing several people from the same village (as they probably would have similar biosecurity practices), a maximum of one farmer was selected from villages with fewer than 10 farms, while villages with 10 farms or more could contribute up to two farmers. Participants were recruited via convenience sampling.

2.6. Recruitment of veterinarians

To ensure a diverse range of participants, the recruitment of field veterinarians followed specific guidelines. A maximum of one field veterinarian was selected from municipalities with fewer than 10 farms. For municipalities with between 10 and 19 farms, up to two field veterinarians were recruited. In municipalities with 20 farms or more, a maximum of three field veterinarians were included. Participants were recruited via convenience sampling. Official veterinarians were included in the study by completing the online questionnaire.

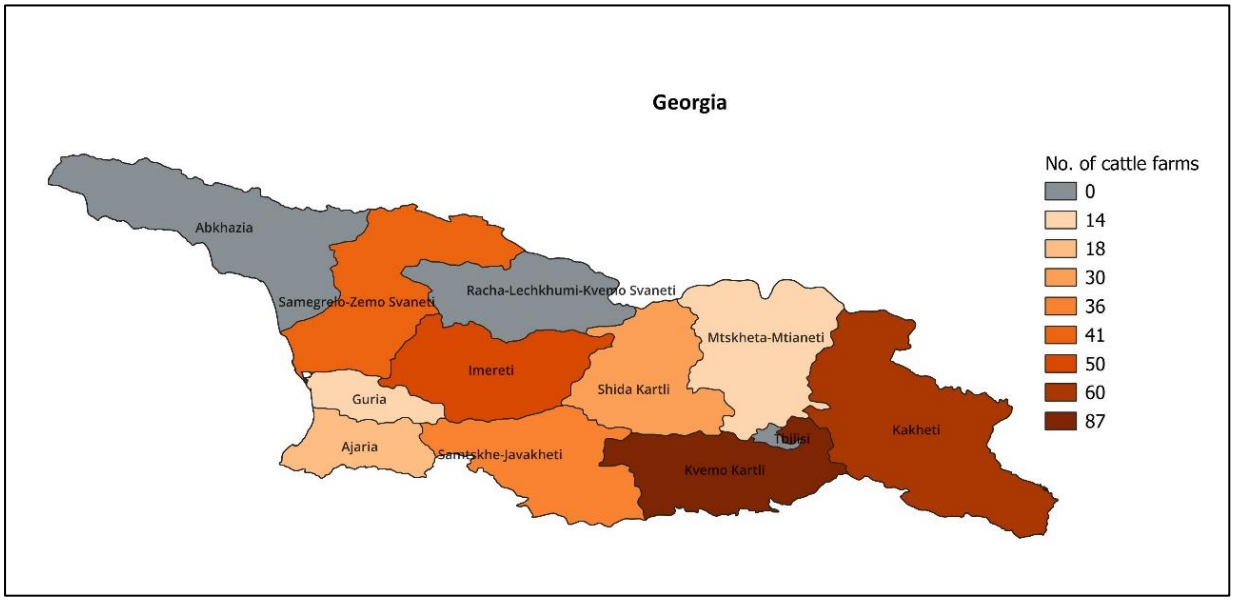

Figure 1. Number of cattle farms targeted to be included in the study across regions

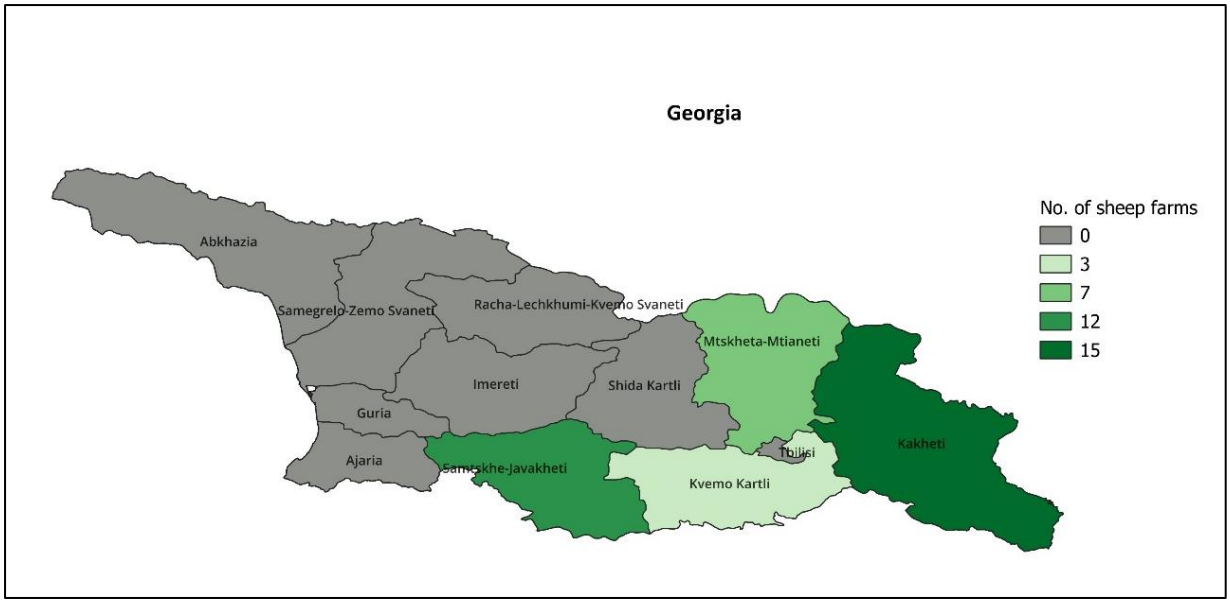

Figure 2. Number of sheep farms targeted to be included in the study across regions

2.7. Variables

The questionnaires encompassed various socio-demographic and professional features such as age, gender, marital status, level of education (for farmers), history of chronic diseases/immune disorders, current professional role, number of years of experience, type of livestock dealing with (for veterinarians), type of production system (for farmers), number of working days in a week (for veterinarians) and number of workers on the farm (for farmers). Zoonoses part inquired about perceived level of knowledge on zoonoses (for veterinarians), understanding of zoonoses (for farmers) and history of zoonotic disease experience. Cleaning and disinfection section explored management of laundry and hygiene facilities on the farm. Additionally, the questionnaires were consisted of a wide range of practices relevant to personal biosecurity measures. To evaluate the implementation level of good general practices for preventing zoonoses, 14 practices for farmers and 15 practices for veterinarians were assessed using a 3-level Likert scale. Moreover, four practices for ensuring healthy livestock were included in the farmers' questionnaire. Furthermore, a 3-level Likert scale was used to measure the implementation level of four types of personal protective equipment (i.e., farm-clothing, gloves, face mask and protective glasses) during various situations (seven for farmers, ten for veterinarians); to assess the perceived risk of contracting zoonoses during afore-mentioned situations; and to understand what motivates farmers and veterinarians to use personal protective equipment and what deters them from using it, together with factors influencing the adoption of PPE and associated challenges. In the final section, communicating on personal

biosecurity measures, education and training needs of farmers and veterinarians were explored by several questions.

2.8. Ethical approval

Ethical approval was obtained from the Universitat Autonoma de Barcelona Ethical Committee (Approval code: 7165).

2.9. Data analyses

Data was exported from the KoBoToolbox platform and then manipulated and organized in Excel®. Three responses were excluded from the veterinarians' analyses due to incomplete data. Sections of 'good general practices for preventing zoonoses, 'good general practices on farm ensuring healthy livestock,' 'implementing personal protective equipment' and questions regarding understanding of zoonoses (for farmers) and perceived level of knowledge on zoonoses (for veterinarians) were treated as response variables. To facilitate comparative analyses, a scoring system was applied to some of the dependent variables. For the section on 'good general practices for preventing zoonoses,' Likert scale levels were assigned points ('always = 2', 'sometimes = 1', 'never = 0'), resulting in an overall score for each study subject ranging from 0 to 28 for farmers and 0 to 30 for veterinarians, based on the sum of assigned scores for all practices. In veterinarians' questionnaire, for the last two general practices for preventing zoonoses, which should be avoided, 0 point assigned to 'always' and 2 to 'never'. In the section on 'good general practices on farm ensuring healthy livestock,' the same Likert scale scoring ('always = 2', 'sometimes = 1', 'never = 0') was used, giving each study subject an overall score ranging from 0 to 8, based on the sum of assigned scores for four practices. The same scoring system was also applied to the section on 'implementing personal protective equipment,' where each study subject received a PPE use score ranging from 0 to 8, based on the sum of assigned points for each situation. In these scoring systems, higher scores represented higher levels of adoption of personal biosecurity measures. Descriptive analyses were used to summarize the data with counts and frequencies. Categorical variables (understanding of zoonoses -for farmers- and perceived level of knowledge on zoonoses -for veterinarians) were compared using the Chi-square test, while numeric variables were compared using the Kruskal-Wallis test which was followed by Dunn test with Bonferroni correction. All statistical analyses were performed using R Commander and RStudio®.

3. RESULTS

3.1. Farmers' results

Socio-demographic features

Although the target sample size was 387 farmers, the service provider ultimately interviewed with 433 farmers face-to-face while adhering to the prescribed instructions and guidelines as closely as field conditions permitted. Over half of the respondents were aged older than 50 and female, and the majority were high school graduates. Two farmers held a Bachelor's degree in agriculture. Almost all were farm owners, with two-thirds having more than ten years of experience in livestock care. Additionally, 84.1% of the respondents reported having no chronic diseases or immune disorders (Table 1).

Table 1. Socio-demographic features of farmers

		n	% †
Age	15-20 years	3	0.7
	21-30 years	11	2.5
	31-40 years	59	13.6
	41-50 years	123	28.4
	≥51 years	237	54.7
Gender	Female	239	55.2
	Male	193	44.5
	I do not want to answer	1	0.2
Marital status	Married	387	89.4
	Not married	46	10.6
Highest level of education	Primary school	6	1.4
	Secondary school	44	10.2
	High school	303	70
	University degree	25	5.8
	Postgraduate degree	55	12.7
Role on the farm	Farm owner	405	93.5
	Salaried employee	13	3
	Other	15	3.5
Years of experience	≤5 years	54	12.5
	6-10 years	93	21.5
	11-20 years	138	31.9
	≥21 years	148	34.2
No of workers	0	102	23.6
	1-5	324	74.9
	6-10	5	1.1
	≥11	2	0.5
Medical history of chronic diseases/ immune disorders	Yes	67	15.5
	No	364	84.1
	I do not want to answer	2	0.5

† Percentage of column

Farm characteristics

Among 433 farms, 72 (16.6%) kept various combinations of large and/or small ruminants, while 361 (83.4%) focused on a single type of livestock. Out of total holdings, 219 farms (50.6%) had dairy cattle, 25 farms (5.8%) raised beef cattle, 72 farms (16.6%) raised cattle for mixed purposes, and 45 farms (10.4%) kept small ruminants. Dairy cattle farms, which constituted roughly the half of the total holdings, were predominantly small-scale, with 91.3% having ≤10 animals. Among the 44 sheep holdings, which were the primary type of small ruminant livestock, 14 farms had ≤10 animals, 30 farms had 11-100 animals; additionally, there were two large sheep farms with 1300 and 2000 animals. Regarding farming systems, beef cattle farms primarily kept animals indoor; dairy cattle farms practiced extensive farming, and sheep farms were nomadic (supp. file 3: Table 1a&1b)

Zoonoses

To evaluate farmers' understanding of zoonoses, they were asked whether they believed it was possible to contract a disease from their animals. The responses were nearly evenly split between yes (51.3%) and no (41.8%), with a small proportion of respondents (6.9%) indicating they were unsure. Those who responded affirmatively were further questioned about which zoonoses they were familiar with. The top four diseases mentioned were brucellosis, anthrax, Crimean-Congo haemorrhagic fever, and ringworm; with several farmers also mentioning rabies. Cryptosporidiosis and leptospirosis were the least known. When asked about the diseases had been diagnosed on their farm or in their region, the farmers identified the top four diseases as brucellosis, anthrax, Q fever, and ringworm. Regarding the history of zoonoses over the past ten years, the vast majority of participants (92.6%) reported no occurrences. Among the 24 people with a history of zoonoses, six had experienced it more than once (supp. file 3: Table 2).

Cleaning and disinfection

Regarding hygiene practices, nearly half of the farmers (48.5%) reported cleaning and disinfecting their farms daily. Additionally, most farmers (41.3%) indicated that they cleaned and disinfected commonly used farm equipment after each use. Almost half of the participants stated that farm-dedicated clothing was cleaned weekly, with the majority washing it separately from their other clothes. As for hygiene facilities on the farm, most of the farmers had a sink, running water, and a bar of soap; just over a half had a changing room, and around a quarter had disposable towels (supp. file 3: Table 3).

Good general practices for preventing zoonoses and ensuring healthy livestock

As indicated in Table 2, many farmers consistently practiced proper hand washing, covered cuts and abrasions, boiled milk, and safely disposed of carcasses. However, a small proportion of respondents neglected hand washing before animal contact and did not avoid consuming raw or undercooked meat. While majority of farmers regularly administered antiparasitic medicines to their pets, about one-third of participants were not always concerned with pets roaming the farms and feeding on viscera. Over 90% of farmers were vigilant in seeking veterinary advice when signs of disease were observed and adhered to the treatments recommended by veterinarians. Additionally, most of them had their animals vaccinated against zoonoses such as brucellosis and anthrax. Three-quarters of the participants always isolated sick animals, while a minority had never implemented this measure.

Implementing personal protective equipment

In general, the implementation level of the four personal protective equipment was high across seven different situations (Table 3). Farm-clothing and gloves were used the most frequently, while protective glasses were the least utilised. Notably, over 70% of the farmers always wore farm-clothing and gloves when handling animals suspected of having a disease, disposing of carcasses, assisting with parturition, and dealing with abortion /disposal of aborted membranes. Nearly one-fifth of the participants always used face mask when contacting with a healthy animal, but around 30% never used it when disposing of carcasses, and assisting with parturition, and managing abortions. Additionally, at least 40% of farmers never used protective glasses in any situations including assisting parturition and disposal of aborted membranes, although nearly 18% always used them when contacting with a healthy animal and 25% when cleaning surfaces and stables.

The PPE use scores generally had a high median value of around six (i.e., 3 out 4 PPE were always applied) across most situations. However, significant lower scores were observed for ‘contact with healthy animals’ and ‘cleaning surfaces/stables’ in comparison with many of the other situations. These differences were confirmed by the Kruskal-Wallis test (p-value < 0.05) and the Dunn test with Bonferroni correction (p-value < 0.025) (Figure 3).

Table 2. Good general practices for preventing zoonoses and ensuring healthy livestock

	Practices	Always n (%) †	Sometimes n (%) †	Never n (%) †
Good general practices for preventing zoonoses	Wash hands before contact with animals	337 (77.8)	83 (19.2)	13 (3)
	Wash hands after contact with body fluids of animals (e.g., blood, abortion materials, etc.)	402 (92.8)	27 (6.2)	4 (0.9)
	If gloves are used, wash hands after contact with animals	365 (84.3)	60 (13.9)	8 (1.8)
	Wash hands before eating, drinking, and smoking	400 (92.4)	32 (7.4)	1 (0.2)
	Wash the wound site after getting a cut or scratch at the farm	393 (90.8)	37 (8.5)	3 (0.7)
	Cover cuts or abrasions on your skin with waterproof bandages	379 (87.5)	47 (10.8)	7 (1.6)
	Boil or pasteurize milk before consumption	389 (89.8)	39 (9)	5 (1.1)
	Wash fruits and vegetables thoroughly before eating or cooking	398 (91.9)	35 (8.1)	-
	Avoid consuming raw or undercooked meat	402 (92.8)	20 (4.6)	11 (2.5)
	Properly manage and dispose of animal waste or carcasses	385 (88.9)	41 (9.5)	7 (1.6)
	Ensure a clean and safe water supply for both animals and human consumption	386 (89.1)	44 (10.2)	3 (0.7)
	Regularly apply antiparasitic medicines to pets	390 (90.1)	42 (9.7)	1 (0.2)
	Not allow pets on the farm	304 (70.2)	89 (20.5)	40 (9.2)
	Not feed pets with viscera	321 (74.1)	74 (17.1)	38 (8.8)
Healthy livestock	Isolate sick animals	326 (75.3)	67 (15.5)	40 (9.2)
	Seek veterinary advice promptly if signs of illness are observed	402 (92.8)	27 (6.2)	4 (0.9)
	Treat infected animals promptly with appropriate medications recommended	418 (96.5)	12 (2.8)	3 (0.7)
	Vaccinate animals against diseases transmissible to humans, e.g. brucellosis	410 (94.7)	22 (5.1)	1 (0.2)

† Percentage of row

Table 3. Implementation level of personal protective equipment by farmers

PPE items / Situations	Farm-clothing n (%) †	Gloves n (%) †	Face mask n (%) †	Protective glasses n (%) †
contact with healthy animals				
Always	279 (64.4)	163 (37.6)	86 (19.9)	77 (17.8)
Sometimes	112 (25.9)	154 (35.6)	116 (26.8)	79 (18.2)
Never	42 (9.7)	116 (26.8)	231 (53.3)	277 (64)
contact with clinically sick animals				
Always	339 (78.3)	291 (67.2)	191 (44.1)	121 (27.9)
Sometimes	63 (14.5)	105 (24.2)	116 (26.8)	108 (24.9)
Never	31 (7.2)	37 (8.5)	126 (29.1)	204 (47.1)
contact with animals suspected of having a disease				
Always	352 (81.3)	324 (74.8)	213 (49.2)	141 (32.6)
Sometimes	55 (12.7)	77 (17.8)	112 (25.9)	110 (25.5)
Never	26 (6)	32 (7.4)	108 (24.9)	181 (41.9)
contact with dead animals/disposing of carcasses				
Always	347 (80.1)	338 (78.1)	229 (52.9)	138 (31.9)
Sometimes	50 (11.5)	60 (13.9)	91 (21)	105 (24.3)
Never	36 (8.3)	35 (8.1)	113 (26.1)	190 (43.9)
assisting parturition				
Always	354 (82.1)	319 (74)	154 (36.4)	94 (22.6)
Sometimes	56 (13)	84 (19.5)	119 (28.1)	101 (24.3)
Never	21 (4.9)	28 (6.5)	150 (35.5)	220 (53)
disposal of aborted placentas and stillbirths				
Always	334 (77.1)	306 (70.7)	186 (43)	125 (28.9)
Sometimes	59 (13.6)	80 (18.5)	113 (26.1)	102 (23.6)
Never	40 (9.2)	47 (10.9)	134 (30.9)	206 (47.6)
cleaning surfaces/stables				
Always	316 (73.3)	254 (58.7)	132 (30.5)	106 (24.5)
Sometimes	90 (20.9)	130 (30)	139 (32.1)	102 (23.6)
Never	25 (5.8)	49 (11.3)	162 (37.4)	225 (52)

† Percentage of column

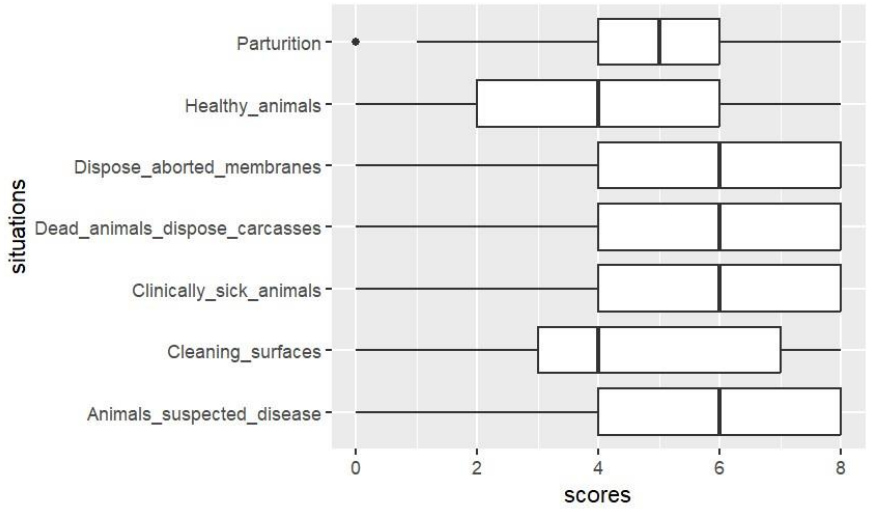

Figure 3. PPE use scores among farmers for various situations

Perceived risk of contracting zoonoses

Contact with healthy animals, assisting parturition, and cleaning surfaces/stables were considered less likely situations to cause zoonosis transmission. However, over 80% of the participants perceived the risk as 'likely' or 'very likely' when contacting animals suspected of having a disease, dealing with dead animals/ disposing of carcasses, contacting clinically sick animals, and disposing aborted membranes/stillbirths (Figure 4).

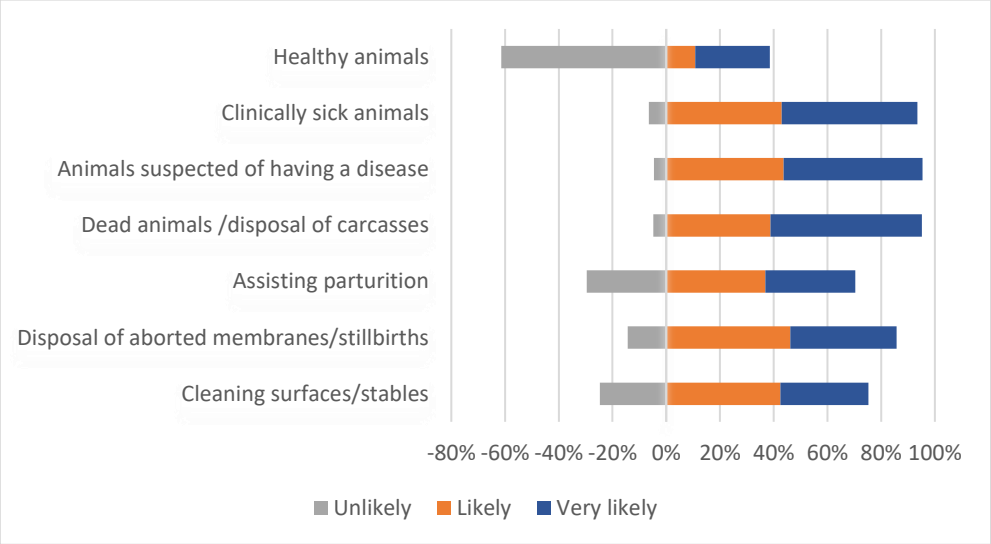

Figure 4. Perceived risk of contracting zoonoses by farmers during various situations

Motivators and obstacles to use PPE

Almost all the proposed items were agreed to some extent by farmers to be a motivator for using PPE. However, over 20% of the farmers disagreed that vulnerability and knowing of others with a history of zoonotic disease encouraged them to use PPE (Figure 5). It aligns with the fact that most of the farmers (84.1%) did not have a chronic disease or immune disorder and majority (92.6%) had not experienced or witnessed a zoonotic disease in the past ten years.

The primary obstacles to use PPE were discomfort and hot or humid conditions, whereas roughly half of the farmers disagreed with statements suggesting that PPE was expensive or difficult to use. Additionally, around 70% claimed that they knew how and when to use PPE (Figure 6).

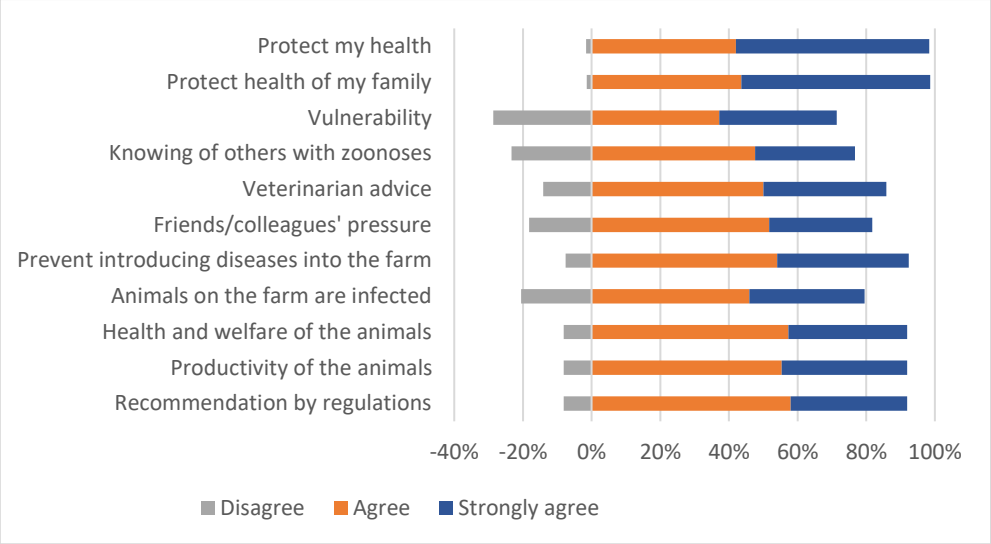

Figure 5. Motivators for using PPE among farmers

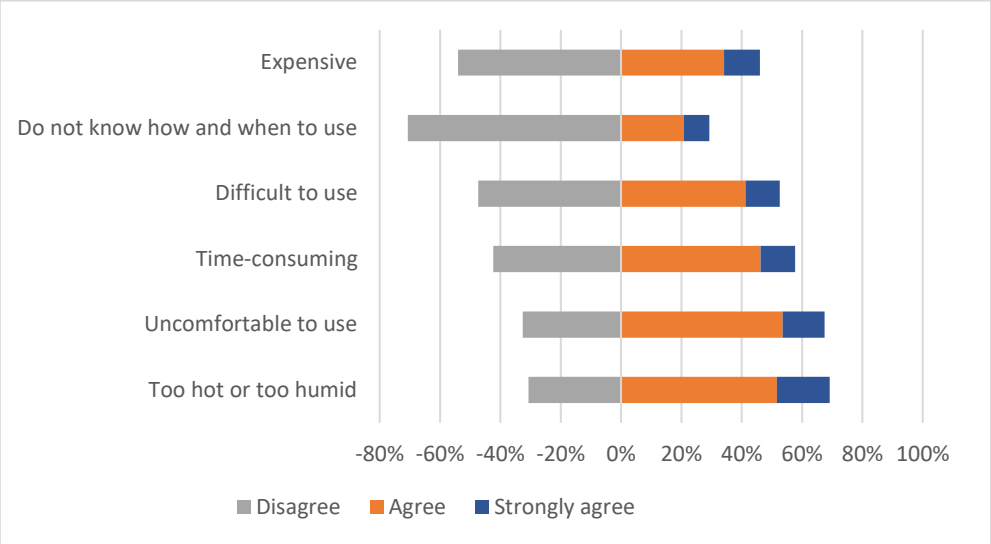

Figure 6. Obstacles to using PPE among farmers

Education and training

In terms of conveying information about PPE, 52.2% of farmers reported that someone had discussed personal protective equipment with them to prevent zoonoses, with most citing private veterinarians and official field veterinarians as the sources of these discussions. However, 47.8% of participants who had not received such discussions suggested that veterinarians might assume farmers already possess this knowledge. Additionally, 90.8% of farmers and their employees had not received any training on zoonoses and preventive measures. Besides, 53.6% of farmers expressed a willingness to learn more about zoonoses and

their prevention, preferring face-to-face sessions and leaflets/brochures for training, with official field veterinarians as the preferred trainers (supp. file 3: Table 4)

Comparative analyses

None of the scores calculated for the any of the response variables for farmers followed a normal distribution (supp. file 3: Table 5). No significant associations were found between farmers' understanding of zoonoses and their socio-demographic or professional characteristics. However, significance tests revealed notable differences in applying personal biosecurity measures across various socio-demographic features. Female farmers tended to score higher in practices related to general zoonosis prevention and PPE use when handling healthy animals. Additionally, participants with higher educational attainment were more likely to score better in PPE use while handling healthy animals and when cleaning surfaces and stables. In contrast, farmers with greatest experience in livestock care scored lower in several personal biosecurity practices, including good general practices on farm ensuring healthy livestock, PPE use when handling healthy and clinically sick animals, assisting parturition, and cleaning surfaces and stables. These findings suggest that both female gender and high educational level positively influence adherence to personal biosecurity measures, whereas increased experience in livestock management may be associated with less compliance to personal biosecurity practices (supp. file 3: Table 5a). Moreover, farmers who engaged in discussions with experts on PPE and zoonoses demonstrated higher adherence to general best practices for zoonosis prevention and ensuring healthy livestock, as well as PPE use when handling healthy and clinically sick animals, and assisting parturition (supp. file 3: Table 5b). Furthermore, significant differences were found between farmers' understanding of zoonoses and the implementation level of PPE across all situations, as well as good general practices for preventing zoonoses and ensuring healthy livestock. Surprisingly, farmers who did not believe that it was possible to contract a disease from their animals tended to score higher in implementing all personal biosecurity measures (supp. file 3: Table 5b). Finally, regarding the obstacles to use PPE, farmers who strongly agreed that PPE is uncomfortable to use had significantly lower scores for PPE usage in all situations, except when handling healthy animals. Similarly, those who strongly agreed that PPE is too hot or humid to wear also showed significantly lower PPE usage scores across all scenarios, except when dealing with healthy and clinically sick animals and during the disposal of aborted placentas and stillbirths (supp. file 3: Table 5c).

3.2. Veterinarians' results

Socio-demographic features

A total of 117 veterinarians were reached, comprising 69 field veterinarians and 48 official veterinarians. However, three responses from the online questionnaire were excluded due to incomplete data, leaving 114 valid responses for analysis. Most respondents were over 40 years old (84.2%), male (69.3%), and married (86.8%). Half of the veterinarians had over 20 years of experience in livestock care. Majority worked 1-2 days per week. Only a few veterinarians (n=11) reported having a chronic disease or immune disorder. Most of the participants cared for beef or dairy cattle, and almost half worked with small ruminants (Table 4).

Table 4. Socio-demographic features of veterinarians

		n	% †
Age	31-40	18	15.8
	41-50	31	27.2
	≥51	65	57
Gender	Female	35	30.7
	Male	79	69.3
Marital status	Married	99	86.8
	Not married	14	12.3
	I do not want to answer	1	0.9
Years of experience	≤10	17	14.9
	11-20	40	35.1
	21-30	26	22.8
	31-40	23	20.2
	≥41	8	7
Weekly working days	1-2 days	55	48.2
	3-4 days	31	27.2
	Daily	28	24.6
Medical history of chronic diseases/ immune disorders	Yes	11	9.6
	No	101	88.6
	I do not want to answer	2	1.7
		n ‡	
Type(s) livestock working with	Beef cattle	97	
	Dairy cattle	100	
	Sheep	50	
	Goat	40	

† Percentage of column

‡ The questions allowed multiple selections. The numbers indicate how many times each item was chosen.

Zoonoses

70.2% of participants perceived themselves as having a high level of knowledge on zoonoses, while 29.8% considered their knowledge to be good. However, only four veterinarians correctly identified zoonotic diseases from the given list. The top four diseases identified as zoonotic were brucellosis, anthrax, Crimean-Congo haemorrhagic fever, and animal tuberculosis together with ringworm. Cryptosporidiosis and leptospirosis were the least known. Seven participants reported experiencing a zoonotic disease in the past 10 years, with mentioning anthrax, brucellosis, Crimean-Congo haemorrhagic fever and ringworm (supp. file 3: Table 6).

Hygiene practices and good general practices for preventing zoonoses

Three-quarters of the veterinarians washed their farm-dedicated clothing daily and separately from their other clothes. This practice was primarily performed at home (83.3%) (supp. file 3: Table 7). Overall, most participants consistently practiced proper hand washing, covered cuts or abrasions, and used sharps containers. However, risky practices such as removing the needle from the syringe by hand and removing the needle cap with mouth, which can cause needle-stick injuries and zoonosis transmission particularly during vaccination, were avoided by only 24.6% and 49.1% of veterinarians, respectively (Table 5).

Implementing personal protective equipment

In general, the implementation level of the four personal protective equipment was very high across ten different situations. Farm-clothing and gloves were used the most frequently, while protective glasses were the least used. Notably, nearly one quarter of veterinarians never used protective glasses during surgery, vaccination, treatment, and sampling; and 1 in 3 during parturition. Additionally, 27.2% never used face masks during parturition (Table 6).

The PPE use scores had a high median value of around 8 in most situations (i.e., four PPE were always applied). However, statistically significant difference was observed in term of PPE use between physical examination of healthy animals and physical examination of animals suspected of having an infectious disease, contact with body fluids of animals, disposal of carcasses, disposal of aborted materials, postmortem examination as shown by the Kruskal Wallis test (p-value < 0.05) and Dunn test with Bonferroni correction (p-value < 0.025) (Figure 7)

Table 5. Good general practices for preventing zoonoses applied by veterinarians

Practices	Always n (%) †	Sometimes n (%) †	Never n (%) †
Wash hands before contact with animals	109 (95.6)	5 (4.4)	-
Wash hands after contact with animals and their body fluids (e.g. blood, abortion materials, foetus, etc.)	114 (100)	-	-
If gloves are used, wash hands after contact with animals	112 (98.2)	2 (1.7)	-
Wash hands after touching equipment contaminated with the body fluids of animals	114 (100)	-	-
Wash hands after removing personal protective equipment	112 (98.2)	2 (1.7)	-
Wash hands with bar soap	101 (88.6)	11 (9.6)	2 (1.7)
Wash hands with liquid/foam soap	105 (92.1)	9 (7.9)	-
Wash hands before eating, drinking, and smoking	111 (97.4)	3 (2.6)	-
Use alcohol-based disinfectants after washing hands	88 (77.2)	24 (21)	2 (1.7)
Use disposable towels to dry hands	88 (77.2)	23 (20.2)	3 (2.6)
Wash the wound site after getting a cut or scratch at the farm	111 (97.4)	3 (2.6)	-
Cover cuts or abrasions on your skin with waterproof bandages	106 (93)	8 (7)	-
Dispose sharps (e.g., needles, etc.) in sharps containers	108 (96.4)	3 (2.7)	1 (0.9)
Remove the needle from the syringe by hand	28 (24.6)	17 (14.9)	69 (60.5)
Remove the needle cap with mouth	56 (49.1)	12 (10.5)	46 (40.3)

† Percentage of row

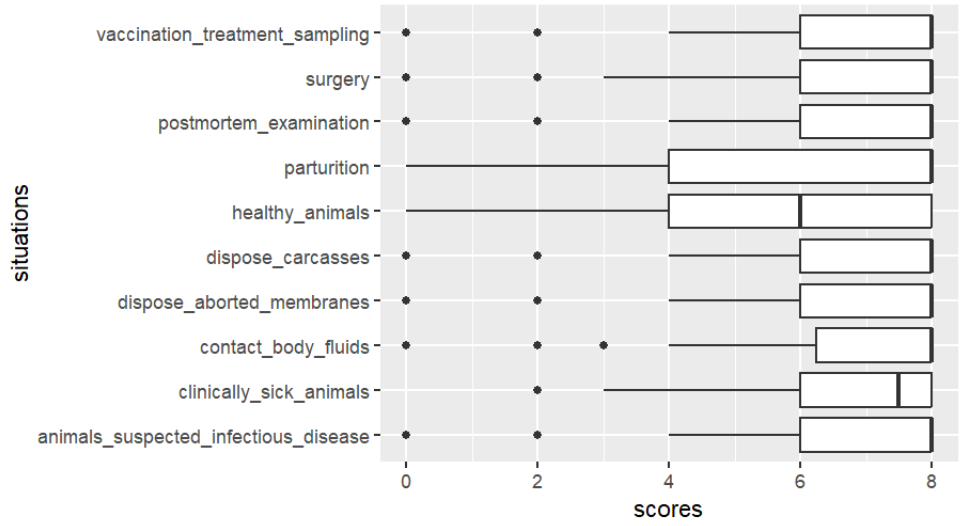

Figure 7. PPE use scores among veterinarians for various situations

Table 6. Implementation level of personal protective equipment by veterinarians

PPE items / Situations	Farm-clothing n (%) †	Gloves n (%) †	Face mask n (%) †	Protective glasses n (%) †
Physical examination of healthy animals				
Always	88 (77.2)	94 (82.5)	59 (51.8)	46 (40.3)
Sometimes	8 (7)	10 (8.8)	23 (20.2)	26 (22.8)
Never	18 (15.8)	10 (8.8)	32 (28.1)	42 (36.8)
Physical examination of clinically sick animals				
Always	102 (89.5)	102 (89.5)	76 (66.7)	63 (55.3)
Sometimes	10 (8.8)	6 (5.3)	21 (18.4)	24 (21)
Never	2 (1.7)	6 (5.3)	17 (14.9)	27 (23.7)
Physical examination of an animal suspected of having an infectious disease				
Always	107 (93.9)	106 (93)	85 (74.6)	73 (64)
Sometimes	2 (1.7)	2 (1.7)	18 (15.8)	20 (17.5)
Never	5 (4.4)	6 (5.3)	11 (9.6)	21 (18.4)
Post-mortem examination				
Always	102 (89.5)	102 (89.5)	91 (79.8)	76 (66.7)
Sometimes	2 (1.7)	6 (5.3)	16 (14)	21 (18.4)
Never	10 (8.8)	6 (5.3)	7 (6.1)	17 (14.9)
Contact with blood, body substances, membranes, faeces, or fluids of animals				
Always	102 (89.5)	108 (94.7)	92 (80.7)	81 (71)
Sometimes	4 (3.5)	3 (2.6)	13 (11.4)	17 (14.9)
Never	8 (7)	3 (2.6)	9 (7.9)	16 (14)
Surgery				
Always	94 (82.5)	93 (81.6)	84 (73.7)	70 (61.4)
Sometimes	2 (1.7)	4 (3.5)	11 (9.6)	15 (13.2)
Never	18 (15.8)	17 (14.9)	19 (16.7)	29 (25.4)
Vaccination, treatment, and sampling				
Always	99 (86.8)	106 (93)	81 (71)	64 (56.1)
Sometimes	4 (3.5)	3 (2.6)	11 (9.6)	21 (18.4)
Never	11 (9.6)	5 (4.4)	22 (19.3)	29 (25.4)
Parturition				
Always	93 (81.6)	94 (82.5)	74 (64.9)	63 (55.3)
Sometimes	3 (2.6)	3 (2.6)	9 (7.9)	12 (10.5)
Never	18 (15.8)	17 (14.9)	31 (27.2)	39 (34.2)
Examination and disposal of aborted foetal membranes and stillbirths				
Always	99 (86.8)	101 (88.6)	87 (76.3)	74 (64.9)
Sometimes	3 (2.6)	3 (2.6)	11 (9.6)	17 (14.9)
Never	12 (10.5)	10 (8.8)	16 (14)	23 (20.2)
Disposal of carcasses				
Always	104 (91.2)	103 (90.3)	93 (81.6)	81 (71)
Sometimes	2 (1.7)	3 (2.6)	8 (7)	11 (9.6)
Never	8 (7)	8 (7)	13 (11.4)	22 (19.3)

† Percentage of column

Perceived risk of contracting zoonoses

Contact with healthy animals and parturition were considered less likely situations to result in contracting zoonoses. However, nearly 90% of respondents perceived the other eight situations as 'likely' or 'very likely' to cause zoonoses (Figure 8).

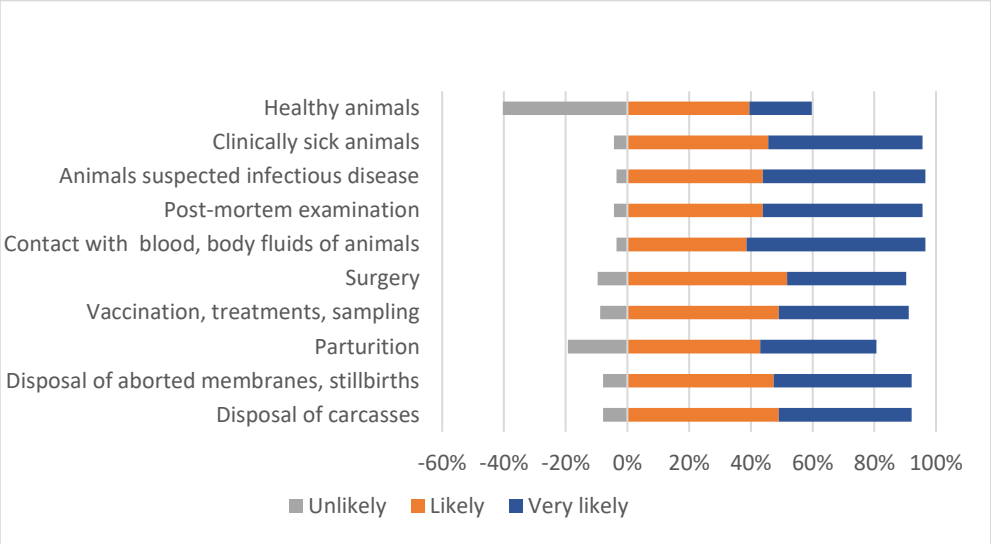

Figure 8. Perceived risk of contracting zoonoses by veterinarians during various situations

Motivators and obstacles to use PPE

Almost all the proposed items were indicated as motivators for PPE use by most veterinarians. However, more than 30% of participants disagreed that 'vulnerability' and 'experience with zoonotic diseases' were motivating factors for adopting PPE (Figure 9). This aligns with the fact that many veterinarians (88.6%) did not have a chronic disease or immune disorder, and most (93.9%) had not experienced a zoonotic disease.

In relation to the obstacles deterring veterinarians from using PPE, nearly two-third of veterinarians agreed or strongly agreed that PPE use is a requirement for farmers. Additionally, most majority of respondents disagreed with statements that PPE use was expensive, difficult, time-consuming, uncomfortable, or too hot and humid. Besides, 83.3% of veterinarians claimed that they knew how and when to use PPE (Figure 10).

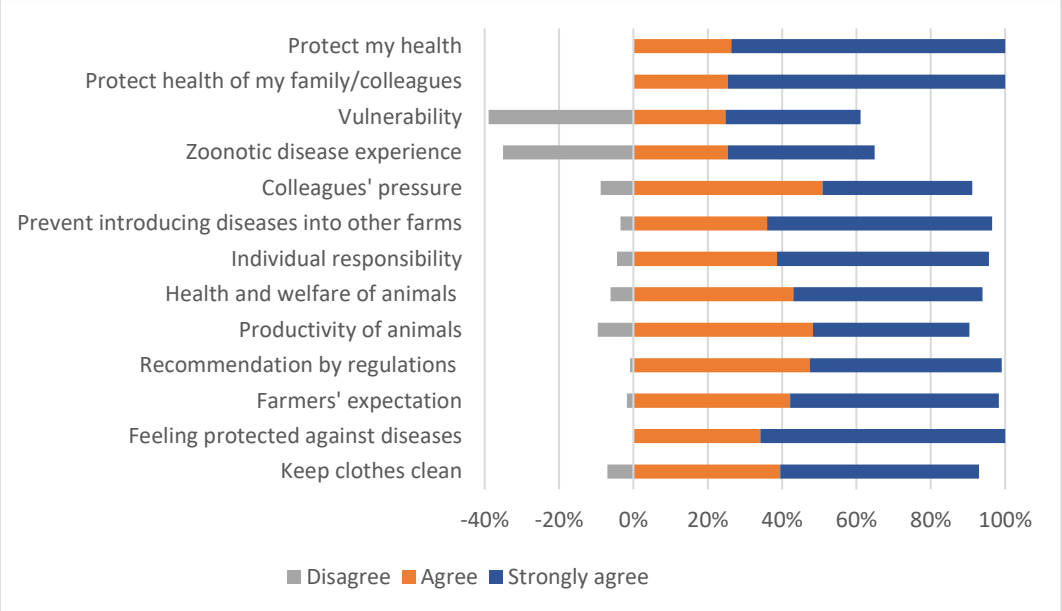

Figure 9. Motivators for using PPE among veterinarians

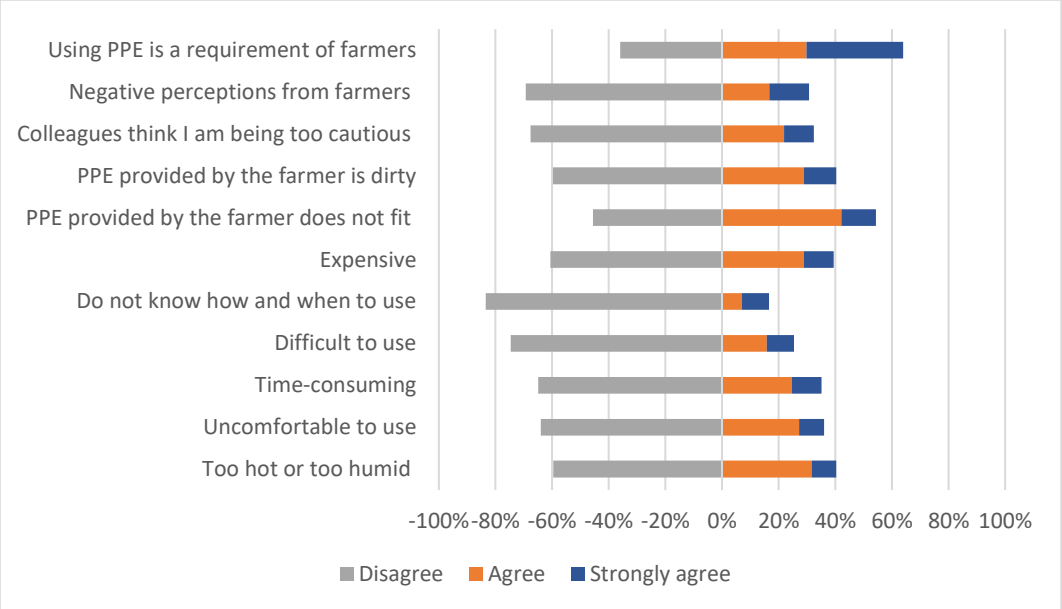

Figure 10. Obstacles to using PPE among veterinarians

Education and training

All veterinarians reported advising farmers and farm employees on personal biosecurity and how to protect themselves from zoonoses. Additionally, 86.8% of participants had received training on zoonoses and preventive measures, and 93.9% expressed an interest in learning

more about the topic. The most desired formats for training were face-to-face sessions and workshop, with official veterinarians identified as the preferred trainers (supp file 3: Table 8).

Comparative analyses

None of the scores calculated for the any of the response variables for veterinarians followed a normal distribution (supp. file 3: Table 9). No significant associations were found between veterinarians' perceived level of knowledge on zoonoses and their socio-demographic or professional characteristics, as well as their history of zoonoses or participation in training. However, field veterinarians were more likely to report a high level of perceived knowledge regarding zoonoses (81.2%) compared to official veterinarians (53.3%) (Table 7). Besides, significance tests revealed notable differences in the implementation level of personal protective equipment across various situations depending on weekly working days, perceived level of knowledge and working either as a field or official veterinarian. Veterinarians working fewer than three days per week tented to score lower in PPE use during physical examination of healthy animals and clinically sick animals; surgery; vaccination, treatments, and sampling procedures; parturition; and disposal of aborted foetal membranes and stillbirths. Conversely, those who perceived themselves as having a high level of knowledge on zoonoses were more likely to score better in PPE use during physical examination of healthy, clinically sick and an infectious disease-suspected animals; surgery; vaccination, treatments, and sampling procedures and parturition. In consistent with the previous result that field veterinarians being more likely to report a high level of perceived knowledge regarding zoonoses, they scored better in PPE use during many of the studied procedures. (supp. file 3: Table 10). These findings suggest that veterinarians who work fewer days may be less consistent in using PPE across a range of situations, additionally, perceived expertise and working in the field are associated with more diligent use of PPE during daily work.

Table 7. Association between veterinary profession and perceived level of knowledge on zoonoses

Veterinary profession	**Knowledge level on zoonoses**		
	Good level n % †	High level n % †	P value
Field veterinarians	13 (18.8)	56 (81.2)	X-squared = 10.076 p-value = 0.001502
Official veterinarians	21 (46.7)	24 (53.3)	

† Percentage of row

4. DISCUSSION

This study represents a pioneering effort in exploring personal biosecurity within the country of Georgia in Caucasus, a region significantly impacted by transboundary animal diseases that exert substantial economic and public health burdens on both humans and animals. The study found that the adoption of personal biosecurity practices among ruminant farmers and veterinarians in Georgia is widespread.

Hand washing, a fundamental practice in personal biosecurity to prevent contracting zoonotic diseases, was consistently applied by majority of the farmers and veterinarians in the current study. Hand washing habits among agricultural workers vary across the globe. In Finland, 70% of veterinarians reported adequate hand washing facilities on farms, and 55% stated they always washed their hands when dirty. However, only 28% consistently used hand sanitizer after removing gloves.[48] Additionally, 62% always washed their hands with soap after examining cattle, and 76% did so after collecting faecal samples.[49] Moreover, 66% of rural veterinarians in three European countries reported always washing their hands after each farm visit, though only 25% used soap.[50] In a study conducted in Sweden, about half of the professionals (52%) cited the lack of water, soap, wash basin and paper towels as barriers to maintaining high biosecurity standards during farm visits.[51] Furthermore, in Arizona, 76% of veterinarians reported always washing their hands before eating or drinking at work, and 89% stated they always used soap and water when doing so.[52] In a Belgian study on veal calf farming, respondents who did not wash their hands before entering the stables considered this practice to be unimportant.[5] In comparison to high-income countries, Georgia had most essential hand washing facilities available, except for disposable towels, and nearly all veterinarians and farmers practiced hand washing in similar situations, much like in neighbouring Türkiye, where 92% of ruminant farmers reported washing their hands.[53] Given that these hygiene facilities can sometimes be lacking in high-income countries, and that proper hand washing is not universally practiced by veterinarians and farmers in those countries, it can be speculated that the availability of hygiene facilities and adherence to proper hand washing during farm work may be more influenced by cultural and moral factors within a community than by a country's economic status.

Boiling or pasteurising milk prior to consumption, which is crucial to prevent the transmission of certain zoonoses such as brucellosis and Q fever, was adopted by most of the Georgian ruminant farmers. Similarly, in the eastern Anatolia region of Türkiye, 77% of cattle farmers boiled milk before consumption;[53] despite the fact that in some villages, most of the

small ruminant farmers consumed freshly made cheese from raw milk.[54] Conversely, one study from Georgia revealed that 74% of participants diagnosed with brucellosis reported consuming unpasteurized milk products.[23] In the same way, in a study conducted in South Africa, two-thirds of the farmers reported regularly consuming unpasteurised milk from their herd.[55] In addition to this, in Cameroon, 84% cattle farmers and veterinary personnel did not concern about consuming raw milk or unpasteurized dairy products.[56] Given that brucellosis was the most identified zoonotic disease and had been diagnosed on many farms in Georgia, participants must be aware of its transmission routes and preventive measures.

To prevent echinococcosis, which is endemic in the Caucasus region, it is important to wash fruits and vegetables thoroughly, avoid eating raw or undercooked meat, and refrain from feeding pet animals viscera. In the current study, the vast majority of farmers reported abstaining from raw meat consumption, a figure similar to their counterparts in Türkiye (87%).[53] Furthermore, over 70% of Georgian farmers claimed to never have allowed pets on their farm nor to feed them with viscera. However, the number of farmers and veterinarians who recognized echinococcosis as a zoonotic disease was surprisingly low, indicating a lack of knowledge about the disease itself despite the high level of adherence to preventive measures. At this point, it is noteworthy that this study was questionnaire-based, and thus, it is uncertain whether the self-reported preventive measures were truly being implemented by the respondents.

The safe disposal of carcasses and proper management of animal waste are crucial to prevent the spread of zoonotic diseases, particularly in countries with a high prevalence of anthrax. In our study, a vast majority of farmers reported implementing such measures, similar to the 91% of cattle farmers in Türkiye who disposed of animal carcasses by burying them deep in soil.[53] However, a European-wide pilot study revealed that only about 60% of cattle farmers implemented proper carcass disposal methods.[57] Given that anthrax is endemic in the Caucasus region and was the second most identified disease by farmers and veterinarians in the current study, it is plausible that agricultural workers in anthrax endemic countries are more likely to implement its preventive measures due to their exposure and familiarity with the disease.

Regarding the PPE implementation, the overall usage of the four types of personal protective equipment (i.e., farm-clothing, gloves, face mask and protective glasses) was consistently high across various situations among both farmers and veterinarians. In contrast to our findings, more than two-thirds veterinarians in the UK and Australia indicated that they do not use any specific PPE when handling healthy animals.[41,58] Likewise, in Nigeria and in the USA (Arizona) only 4% and 17% of veterinarians used appropriate PPE when examining

apparently healthy animals, respectively.[52,59] When assisting with parturition, more than 96% of Finnish veterinarians never used a mask while helping cows during calving.[49] Similarly, in the USA, less than 5% of veterinarians used respiratory or eye protection during parturition.[39] In contrast, nearly 20% of veterinarians in Nigeria used adequate PPE while assisting with deliveries.[52] Regarding the handling of abortions, one study on Q fever in Cameroon revealed that only 6% of cattle farmers and 41% of veterinarians used gloves and masks.[56] In the current study, at least 55% of veterinarians consistently used four PPE items and at least 70% of farmers always used farm-clothing and gloves, with at least 22% also wearing masks and protective glasses during parturition and when managing aborted materials. Related to the farm-specific clothing, similar to the findings of our study, 91% of cattle veterinarians in Finland reported consistently wearing protective coats.[48,49] As for collecting samples, in contrast to the current study, where at least 56% of veterinarians consistently used four PPE items while doing so, 95% of Finnish veterinarians never used a mask as collecting faecal samples from cattle.[49] About surgery and necropsy, previous studies indicated high proportion of overall PPE utilization (from 75% to 96%) among veterinarians.[41,52,58] However, in relation to the specific PPE item, 83% of large animal veterinarians in the USA did not use respiratory protection during surgical procedures, and 96% failed to use respiratory or eye protection when performing necropsies or handling tissues.[39] Similarly, in Nigeria, approximately a quarter of veterinarians used adequate PPE during surgery and post-mortem examinations.[59] Besides, a study among rural veterinarians in three European countries found that 60% used disposable calving gowns during surgery.[50] With regard to using gloves, only 30% of European rural veterinarians and 9% of Finnish ambulatory livestock veterinarians always used it during farm visits.[48,50] Beyond the usage of PPE in various situations and contexts, the literature offers other valuable insights on the topic. For instance, in Belgium, it was proved that despite the availability of basic PPE on most farms, their usage by farmers was infrequent.[60] Moreover, in Australia, more than half of the veterinarians reported implementing stringent infection control practices only when they deemed them necessary.[58] These findings suggest that PPE usage in farming may be influenced by the presence of zoonotic diseases on the farm or in the country. Additionally, it might be challenging to establish a standardized PPE protocol for specific situations or veterinary procedures, as preventive measures must be adjusted based on the individual case.[10]

Although PPE usage among farmers was relatively high, it was surprising that 41.8% of the farmers in the current study did not believe that they could contract diseases from their animals. In a study conducted in a neighbouring country of Georgia, 80% of Turkish cattle

farmers reported awareness of diseases transmitted from animals to humans, although it was unclear whether they believed that this posed a risk to them personally.[53] In both countries, when asked to name the zoonotic diseases they were familiar with, many farmers mentioned anthrax, brucellosis, and CCHF, which are endemic to the region. The lack of understanding and awareness of zoonotic diseases among Georgian farmers may arise from three perceptions. First, they may not believe that any animals can transmit diseases to humans. Second, they may perceive their animals as healthy and incapable of spreading disease. Third, they may not see themselves as vulnerable to contracting such diseases. Supporting the second viewpoint, 20.5% of farmers disagreed that knowing their animals are infected with zoonotic diseases motivates them to protect themselves. In line with the third view, 28.6% of farmers disagreed that having health issues that increase their vulnerability to zoonotic diseases encourages them to use PPE. Indeed, our study population primarily consisted of individuals over 40 years old living in rural areas and only 15.5% of farmers and 9.6% of veterinarians had been diagnosed with a chronic disease. In addition to that, only 5.5% of farmers and 6.1% of veterinarians reported having experienced a zoonotic disease in the past ten years. These rates are lower than recent findings, which report 15% among South African farm workers,[55] Finnish veterinarians,[49] and Greek small ruminant farmers.[61] These findings suggest that many participants in our study population may be unaware of their health conditions including zoonotic disease experience, possibly due to limited access to healthcare or a reluctance to seek medical advice.

The majority of participating veterinarians in our investigation perceived their knowledge of zoonotic diseases to be high, with none claiming to have no knowledge. However, many struggled to correctly identify zoonotic diseases, with 80% failing to recognize echinococcosis, an endemic disease in the country. Additionally, some veterinarians incorrectly identified non-zoonotic infectious conditions as zoonoses. These findings are noteworthy, especially since 86.8% of the veterinarians reported having received training on zoonoses and their prevention. Similar studies have reported varying levels of veterinarians claiming high knowledge of zoonoses; such as 10% in Finland,[49] 42% in Australia,[58] 85% in the UK,[41] and 92% in the USA (Arizona).[52] It's important to recognize that self-assessment of knowledge among clinical professionals is highly subjective, with no clear definitions for what constitutes high, good, or poor levels of knowledge. However, the follow-up question in this research suggests the presence of a knowledge gap about zoonoses among veterinarians.

Proper cleaning and disinfection practices are essential to prevent indirect transmission of any infectious diseases. Throughout this research, farmers demonstrated strong awareness of maintaining daily farm hygiene, ensuring equipment was cleaned after each use, and

managing laundry effectively. Similarly, most veterinarians were diligent about washing their farm-specific clothing daily and separately from their other garments. Aligned with Georgian farmers, 95% of dairy farmers in the UK maintained general farm cleanness and hygiene.[62] Additionally, 84% of veterinarians in Australia and all veterinarians in the UK believed that practicing good equipment hygiene was an effective way to reduce the risk of zoonotic disease.[41,58,63] However, a study conducted across three European countries found that 58% of veterinarians only changed their clothes when visibly dirty or less often than daily. Despite this, they acknowledged that this practice was among the top five personal biosecurity measures needing improvement in their work.[50] Beyond these self-reported studies, an observational study in Wisconsin among dairy farm workers found that 63% of farmers laundered their work clothes before leaving the farm.[64] Some studies have shown that biosecurity practices aimed at preventing direct pathogen transmission are perceived as more effective than those addressing indirect transmission (e.g., through equipment, clothing, or stables),[65,66] and farmers often lack understanding of how infectious agents spread through indirect contact.[51] Unlike, the farmers and veterinarians within our study appeared to place significant importance on these practices. One possible explanation for this could be previous experiences with disease outbreaks, which have emphasized the importance of cleaning and disinfection.[67]

The current study also investigated good general practices that can help prevent disease transmission between animals and ensure healthy livestock. A high proportion of Georgian farmers (more than 90%) demonstrated vigilance in seeking veterinary help when any signs of disease were observed, which is comparable (91%) to the attitude of Turkish farmers.[53] In addition to that, three-quarters of farmers consistently isolated sick animals, in contrast to a European-wide pilot study that found less than 40% of cattle farmers practiced isolation of sick animals.[57] On this matter, UK and Belgian studies pointed out that although cattle farmers valued isolation of sick animals as an effective biosecurity measure, they also found it challenging to implement due to lack of space.[65,67,68] Similar concerns were raised by Ugandan farmers who highlighted the need for extra land and labour to isolate animals and time constraints.[69] With respect to vaccination of livestock against zoonoses, almost all participating farmers reported vaccinating their animals either always or sometimes. Regarding this, a UK study found that dairy farmers preferred vaccination to control the effects of disease currently circulating on their farm (67%) compared to preventing the occurrence of a disease not yet present (45%).[62] The present study reported high level of vaccination for livestock, whether for prevention or control of disease, which could be attributed to various state and municipality-

led vaccination campaigns implemented across the country since 2013. These campaigns were initiated following disastrous experiences resulting from delegating the responsibility of vaccinating animals to livestock owners in 2007, leading to valuable lessons learned (Personal communication, Mikheil Sokhadze).

According to the health belief model, the adoption of preventive health behaviours is influenced by an individual's belief in a personal threat, which is shaped by their perceived susceptibility to and severity of the threat (perceived risk), as well as the belief in the effectiveness of the preventive behaviour, which is determined by the perceived benefits of it (motivators) and any barriers to its implementation (obstacles).[70,71] In this study, both farmers and veterinarians viewed the risk of contracting zoonoses as less likely when handling healthy animals and assisting with parturition. Correspondingly, lower PPE use scores were recorded for these activities. Additionally, farmers and veterinarians had the most disagreement on whether vulnerability and experience with zoonotic diseases were motivators for using PPE. In consistent with this finding, a European-wide study revealed that risk perception, in terms of disease susceptibility and severity, did not have a significant impact on the implementation of biosecurity measures.[57] Even if a risk is recognized, individuals who do not feel personally vulnerable may lack the motivation or intention to change their behaviour regarding health protection.[41,58] Furthermore, the vast majority of the Georgian participants in the current study viewed protecting their own health and that of their families as a primary motivation to use PPE. Similar findings were observed in Australian and British studies, where veterinarians expressed concern about the risk of contracting zoonoses for themselves and their colleagues, identifying personal risk as a primary reason for PPE use.[41,58] In relation to barriers, previous studies have identified several obstacles to veterinarians adopting PPE including cost, concerns about heat stress, safety issues, time and stress management challenges, lack of resources, and negative perceptions from colleagues who might consider them unnecessarily cautious for using PPE.[41,51,58,72,73] Regarding negative client perceptions about veterinarians wearing PPE, some studies have shown that it can be a deterrent factor[58] while others indicated such perceptions had no influence on the decision to use PPE.[41,59] Conversely, almost all veterinarians in the present study considered meeting farmers' expectations as a motivating factor for using PPE. As for farmers, obstacles to PPE adoption include high costs, time consumption, feasibility and practicality issues, labour challenges, and a lack of information and training.[4,10,62,67–69,72–74] In consistent with the literature, participating farmers in our analyses confirmed that issues like discomfort, excessive heat, or humidity make PPE use challenging, leading to lower compliance. Surprisingly, more than 60% of the veterinarians and

45% of the farmers in the current study disagreed that PPE was expensive and difficult to use, and over 70% agreed that they knew how and when to use PPE. This may be attributed to numerous livestock projects in Georgia funded by international organizations following outbreaks, as well as the fact that donor organizations provide PPE to farmers, and veterinarians receive PPE at no cost from the government (Personal communication, Mikheil Sokhadze). In addition to personal beliefs and judgments that influence the decision to use PPE, regulations may also play a role. Previous studies have indicated that both veterinarians and farmers support the use of higher authority and legislation to encourage PPE adoption.[4,41,69,72,73] They felt that desired outcomes cannot be achieved without action from others, including farmers and veterinarians as well as government bodies, and liability measures ensure widespread biosecurity compliance, making farmers and veterinarians more likely to take responsibility for using PPE as part of a collective effort. In consistent with this view, almost all veterinarians and 91.9% of farmers in the present study agreed or strongly agreed that regulations served as motivators for using PPE. According to the health belief model and the theory of planned behaviour, individuals' decisions to adopt infection prevention measures are primarily influenced by their perceptions of the effectiveness and practicality of recommended strategies, their ability to implement these measures, and their sense of control over disease prevention.[70] Therefore, it is uncertain whether strict regulations and legislation alone will effectively ensure that farmers or veterinarians fully implement personal biosecurity measures in the field. While regulations may assist, they are unlikely to be the sole solution. Interestingly, while all veterinarians in the present study viewed the use of PPE as an individual responsibility, 64% also believed it was the farmers' responsibility. Similarly, although in Belgium 87% of cattle farmers considered themselves responsible for implementing of biosecurity on their farm,[68] a study of Swedish farms highlighted a gap in understanding the responsibilities of farmers versus professional visitors, suggesting the need for clearer delineation.[51] Since personal biosecurity measures are designed to prevent zoonotic pathogens from spreading to humans (bio-prevention), they must be adopted by all stakeholders who interact with animals, including farmers, veterinarians, salespeople, and truck drivers. Thus, the ultimate goal should be to view biosecurity as a collective responsibility.[68]

To ensure high levels of biosecurity, regular monitoring and ongoing personnel training are crucial.[9,50] A recent study in the USA showed that veterinarians familiar with the current biosecurity guidelines had higher odds of perceiving biosecurity practices as practical while handling animals in day-to-day practice.[75] Similarly, Venkat et al found out that 85% of veterinarians agreed or strongly agreed that they would benefit from receiving continuing

education or guidelines on zoonotic diseases and infection prevention practices.[52] In the same way, some studies identified lack of information and advice as the primary reasons why farmers did not implement biosecurity measures.[76,77] In our investigation, 86.8% of veterinarians reported having received training on zoonoses and their prevention, whereas 90.8% of farmers claimed not having received such training. Previous studies have shown contrasting results compared to the current study. For instance, only 34% of cattle veterinarians in Nigeria and 9% in the UK attended PPE training seminars since starting their practice.[59,72] Similarly, a study of rural veterinarians across three European countries revealed that 23% had not received any training after graduation, 14% had obtained training as part of their veterinary curriculum, and 36% gained knowledge through continuing education and post-graduate readings.[50] Preferences for sources of education vary widely according to the literature, including veterinary journals, textbooks, and government bulletins,[58] as well as websites, presentations, and flyers or brochures.[52] In our study, both farmers and veterinarians favoured face-to-face sessions for this purpose. Regarding personal biosecurity communication, in the present study, 47.8% of the farmers reported that no one had discussed the topic with them, with many suggesting that veterinarians might assume farmers already possess the necessary knowledge; while all veterinarians indicated that they had advised farmers or employees on personal biosecurity. The discrepancy may have arisen because farmers might not have recalled or recognized the advice given by veterinarians, or veterinarians might have assumed that their advice was understood and, as a result, may not have reinforced it effectively and consistently. In Canada, fewer than one-quarter of dairy farmers reported discussing various biosecurity practices with a veterinarian;[66] while in the UK, 92% of veterinarians provided advice to cattle producers on on-farm biosecurity.[78] In our study, farmers who reported having these discussions identified private or field veterinarians as their sources of information, which aligns with previous researches indicating that veterinarians are the primary source of information for farmers.[4,50,67,72,76] However, some studies suggest that other professionals such as external consultants might be more effective in providing biosecurity information and underlined that herd veterinarians, due to their frequent visits, might overlook obvious issues.[68,73]

Each farmer and veterinarian have a unique mix of demographic factors, professional attributes, past experiences, routines, and goals, along with economic, cultural, and family influences. These individual characteristics shape their perspectives on animal health, prevention, and control strategies, and impact their decision-making.[70] Although this study did not demonstrate such an association, a Greek study found that a history of zoonotic disease, specifically brucellosis, was linked to higher biosecurity scores on farms and more frequent

isolation of sick animals.[61] Our study found that female farmers were more likely to score higher in implementing certain personal biosecurity measures. A similar association was observed in another study, where male veterinarians were linked to lower precaution awareness rankings.[39] Additionally, while none of the demographic variables and training experience in our study were associated with veterinarians' level of knowledge about zoonoses, a recent study revealed that knowledge scores were lower for female veterinarians and higher for those who had received biosecurity training.[75] In the present study, farmers with higher educational levels were more likely to score higher in implementing certain personal biosecurity measures. This finding aligns with previous studies that have shown a higher educational level is associated with increased knowledge about zoonoses and a more positive attitude toward implementing personal biosecurity measures.[53,57,66] Furthermore, it was observed in this study that farmers with greater experience in livestock care scored lower on several personal biosecurity measures. While knowledge about a measure does not necessarily equate to its practical application, a study in Cameroon similarly revealed that increased years in the farming sector were negatively associated with knowledge of specific zoonoses.[56] Besides, although age does not directly correlate with experience, a study in Ireland found that younger farmers were more than twice as likely as their middle-aged counterparts to implement biosecurity guidelines.[76]
It is note-worthy that farmers having informal discussions on PPE in the context of zoonosis prevention were scored higher in PPE usage across multiple scenarios. In contrast, formal training sessions did not demonstrate a similar effect. This finding suggests that informal, day-to-day communication may have a greater influence on farmers' PPE usage practices compared to structured training programs. In this research, veterinarians who worked fewer days per week scored lower in PPE use across many situations. This may be linked to the belief that less frequent exposure to risk justifies a less rigorous application of preventive measures. What is more, in the present study, field veterinarians were more likely to perceive themselves as having a high level of knowledge about zoonoses, and individuals with higher self-perceived knowledge regarding zoonoses exhibited better PPE usage across multiple scenarios. These findings suggest that fieldwork experience, as opposed to working in an official veterinary capacity, may positively influence both knowledge and the adoption of appropriate protective practices.

Finally, one of the surprising findings of this study is that farmers who believed it was not possible to contract a disease from their animals tended to score higher in implementing various personal biosecurity measures. A similar contradiction was observed in a recent study in the USA, where veterinarians who believed that they could transmit disease to animals were

less likely to wear protective clothing when handling confirmed cases of zoonotic diseases.[75] These contradictions may stem from the subjectivity involved in self-evaluating PPE use. In consistent with this view, a study among rural veterinarians in three European countries revealed that participants received the lowest implementation scores for the biosecurity measures they believed they managed correctly.[50] Similarly, a study of veal calf farmers in Belgium found that most respondents considered biosecurity important, despite being unfamiliar with the term itself.[5] If it is assumed that farmers accurately self-evaluated and genuinely implemented these biosecurity measures without recognizing the potential for animal diseases to be transmissible to humans, it suggests they may not fully understand the rationale behind personal biosecurity, even though they practice it. This indicates a knowledge gap among farmers regarding zoonoses and their prevention.

This study also has some limitations. Since a complete dataset of registered livestock households was unavailable for random sampling, a convenient sampling method was used. As a result, there may be selection bias, and the data might not fully represent all farmers and veterinarians in the country. In addition to that, previous studies have shown that biosecurity measures differ between cattle and small ruminant farms; however, due to the unsuitability of the data, this comparison could not be made in the current study. Since half of the farms included were dairy farms, and most of them were small-scale, the results may have overrepresented a single type of livestock farming. Furthermore, it is unclear whether there were differences between those who participated and those who did not. If the perceptions and practices of participants differed systematically from non-participants, this could have introduced response bias, potentially affecting the study results. Lastly, as with any questionnaire-based research, one of the limitations of this study is that self-reported behaviours may not accurately represent actual practices. In particular, social desirability bias is common in studies on self-reported data, often leading to an overestimation of compliance.

Nevertheless, this research has provided a comprehensive understanding of personal biosecurity practices across the country of Georgia. Importantly, the authors believe that the study played a key role in raising awareness about zoonotic diseases and how to prevent them. This was further reinforced through the distribution of educational leaflets, thereby contributing not only to the research objectives but also to the broader goal of improving public health in the region.

5. CONCLUSIONS

This study has demonstrated that in the country of Georgia, the use of personal protective equipment for infection prevention is widespread among farmers and veterinarians, as well as relevant biosecurity measures to prevent endemic zoonoses, such as brucellosis, anthrax, and echinococcosis, are widely practiced. Most farmers and veterinarians reported regularly practicing key measures, such as hand washing, avoiding feeding pets viscera, proper carcass disposal, and using personal protective equipment when handling animals in various situations. However, even with the potential overestimation inherent in self-reported questionnaire, the lack of adequate protective equipment, such as face masks or protective glasses, used by many farmers and veterinarians in high-risk situations like managing aborted materials; along with the belief held by several farmers that animals cannot transmit diseases; as well as the perception that parturition was less likely situation to cause zoonoses; and the gaps in knowledge about zoonoses warrant further attention. Although the population seems highly motivated to comply with infection prevention measures to protect their health and the health of their families, future research should prioritize the development of assessment tools to objectively evaluate the implementation level of personal biosecurity practices, assess knowledge of zoonoses, and identify specific gaps. Such campaigns could integrate the *One Health* approach, stressing the connections between human, animal, and environmental health.

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7. ANNEXES

SUPPLEMENTARY FILE 1

Personal Biosecurity Questionnaire for Farmers

Introduction

This questionnaire is intended for the person at the farm who has more contact with the animals.

Please read aloud to the interviewee:

"This questionnaire will take approximately 20 minutes to complete. It covers farm characteristics, farmer/employee characteristics, diseases, general practices on the farm and implementation of personal protective measures and understanding of the concept.

We would like to understand the practices that you implement on the farm to protect yourself from getting infected with diseases from animals and why do you decide to implement them or not.

Most of the questions are single or multiple choice. Please answer all the questions.

Before we start, please confirm that you have read and signed the consent form.

Please note that your answers to this questionnaire will be anonymous."

Name/ID of the interviewer: Date of survey:

Location: Province: District: Village:

Language of the interview: *(single choice)*

□ Georgian □ Armenian □ Azerbaijani □ Other (please specify)

A. Farm characteristics

1. What type(s) of livestock and production system do you have on your farm and what is the current herd size (taking into account the adult animals only)? Select all that apply. *(multiple choice)*

Type of livestock	Type of production system	Herd size
Beef cattle	☐ Nomadic/transhumance ☐ Always kept indoor ☐ Extensive ☐ Semi-extensive ☐ Other…	
Dairy cattle	☐ Always kept indoor ☐ Extensive ☐ Semi-extensive ☐ Other…	
Cattle of mixed purpose	☐ Always kept indoor ☐ Extensive ☐ Semi-extensive ☐ Other…	
Sheep	☐ Nomadic/transhumance ☐ Always kept indoor ☐ Extensive ☐ Semi-extensive ☐ Other…	
Goat	☐ Nomadic/transhumance ☐ Always kept indoor ☐ Extensive ☐ Semi-extensive ☐ Other…	

B. Socio-demographic features

2. What is your age? *(single choice)*
□ 15-20 □ 21-30 □ 31-40 □ 41-50 □ ≥51

3. What is your gender? *(single choice)*
□ Man □ Woman □ I do not want to answer

4. What is your marital status? *(single choice)*
□ Married □ Not married □ I do not want to answer

5. What is your highest level of education? *(single choice)*
□ Illiterate □ Primary school □ Secondary school
□ High school □ University degree □ Postgraduate degree

5.1. If you have a bachelor degree, is your education related to agriculture? *(single choice)*
□ Yes □ No

6. What is your role on the farm? *(single choice)*
□ Farm owner □ Salaried employee □ Other (please specify) ……

7. How long have you been handling livestock? *(single choice)*
□ ≤5 years □ 6-10 years □ 11-20 years □ ≥21 years

8. How many people (apart from you) work on the farm? *(single choice)*
□ 0 □ 1-5 □ 6-10 □ ≥11

9. Do you have any chronic diseases (diabetes, hypertension, chronic kidney disease, etc.) or immune disorder (rheumatoid arthritis, inflammatory bowel disease, multiple sclerosis, etc.)? *(single choice)*
□ Yes □ No □ I do not want to answer
If yes, please specify……

C. Zoonoses

10. Do you think it is possible for you to get a disease from your animals? *(single choice)*
□ Yes □ No □ I do not know

10.1. If yes, which diseases do you know can be transmitted from animals to humans? Select all that apply. *(multiple choice)*
□ Other, please specify……

11. Which of the following diseases have been diagnosed in your farm or region? Select all that apply. *(multiple choice)*
□ Anthrax
□ Brucellosis
□ Ovine chlamydiosis
□ Ringworm
□ Animal tuberculosis

□ Ecthyma contagiosum (Orf)
□ Crimean Congo Haemorrhagic fever
□ Cryptosporidiosis
□ Leptospirosis
□ Cowpox
□ Echinococcosis
□ Q Fever
□ Other, please specify…….

12. Have you or anyone working in your farm got a disease from the animals in the last 10 years? *(single choice)*

□ Yes □ No □ I do not know

12.1. If yes, how many times in the last 10 years? *(single choice)*

□ 1 □ 2 □ 3 □ >3

12.2. If yes, what were the symptoms? Select all that apply. *(multiple choice)*

Disease event 1	Disease event 2	Disease event 3
□ Fever	□ Fever	□ Fever
□ Weakness, weight loss, headache, body ache	□ Weakness, weight loss, headache, body ache	□ Weakness, weight loss, headache, body ache
□ Diarrhoea, abdominal discomfort, nausea, vomiting	□ Diarrhoea, abdominal discomfort, nausea, vomiting	□ Diarrhoea, abdominal discomfort, nausea, vomiting
□ Cough, chest pain, shortness of breath	□ Cough, chest pain, shortness of breath	□ Cough, chest pain, shortness of breath
□ Skin lesions	□ Skin lesions	□ Skin lesions
□ Joint pain	□ Joint pain	□ Joint pain
□ Other, please specify……	□ Other, please specify…….	□ Other, please specify……

D. Cleaning and disinfection

13. How often do you clean/disinfect your farm? *(single choice)*

□ Daily □ Once a week □ Every other week □ Monthly □ Once a year

14. How often do you clean/disinfect commonly used farm equipment? *(single choice)*

□ After every use □ Daily □ Once a week
□ Every other week □ Monthly □ Once a year

15. Do you have…? *(all items; single choice for each item)*

Item	Yes	No	Yes, but I do not use it
A changing room on your farm	□	□	□
A sink with	□	□	□
running water	□	□	□
a bar of soap	□	□	□
a liquid/foam soap dispenser	□	□	□
alcohol-based disinfectants	□	□	□
disposable towels	□	□	□
hand dryer	□	□	□

16. How often do you wash your farm dedicated clothing? *(single choice)*

□ Daily □ Weekly □ Monthly □ Rarely □ Never

17. When you wash your farm dedicated clothing, do you wash them separately from your other clothes? *(single choice)*

□ Yes □ No

E. Good general practices for preventing zoonoses

18. Please indicate how frequently do you apply following practices: *(all measures; single choice for each measure)*

Practices	Always	Sometimes	Never
Wash hands before contact with animals	□	□	□
Wash hands after contact with body fluids of animals (e.g., blood, abortion materials, foetus, etc.)	□	□	□
If gloves are used, wash hands after contact with animals	□	□	□
Wash hands before eating drinking and smoking	□	□	□
Wash the wound site after getting a cut or scratch at the farm	□	□	□
Cover cuts or abrasions on your skin with waterproof bandages	□	□	□
Boil or pasteurize milk before consumption	□	□	□
Wash fruits and vegetables thoroughly before eating or cooking	□	□	□
Avoid consuming raw or undercooked meat	□	□	□
Properly manage and dispose of animal waste or carcasses	□	□	□
Ensure a clean and safe water supply for both animals and human consumption	□	□	□
Regularly apply antiparasitic medicines to pets	□	□	□
Not allow pets on the farm	□	□	□
Not feed pets with viscera	□	□	□

F. Good general practices on farm ensuring healthy livestock

19. Please indicate how frequently do you implement the following practices: *(all practices; single choice for each practice)*

Practices	Always	Sometimes	Never
Isolate sick animals	□	□	□
Seek veterinary advice promptly if signs of illness are observed	□	□	□
Treat infected animals promptly with appropriate medications as recommended by a veterinarian	□	□	□
Vaccinate animals against diseases transmissible to humans, e.g. brucellosis and anthrax	□	□	□

G. Implementing personal protective equipment

20. How often do you implement personal protective equipment during the following situations? *(all practices; single choice for each practice)*

Situations	Farm -clothing	Gloves	Face masks	Protective glasses
Contact with healthy animals (e.g. during hoof trimming, shearing, assisting vet for vaccinating animals, etc.)	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time-consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time-consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time-consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time-consuming • Other…..
Contact with clinically sick animals	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time-consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Contact with animals suspected of having a disease	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Contact with dead animals and disposal of carcasses	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Assisting parturition	☐ Always ☐ Sometimes	☐ Always ☐ Sometimes	☐ Always ☐ Sometimes	☐ Always ☐ Sometimes

	☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Disposal of aborted placenta and stillbirths	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Cleaning surfaces/ stables	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..

H. Perceived risk of contracting zoonoses

21. In your view, how likely can you get a disease from an animal when the following situations are carried out on the farm? *(all practices; single choice for each practice)*

Situations	Very likely	Likely	Unlikely
Contact with healthy animals	☐	☐	☐
Contact with clinically sick animals	☐	☐	☐
Contact with an animal suspected of having a disease	☐	☐	☐
Contact with dead animals and disposal of carcasses	☐	☐	☐
Assisting parturition	☐	☐	☐
Disposal of aborted foetal membranes and stillbirths	☐	☐	☐
Cleaning surfaces/stables	☐	☐	☐

I. Motivators for and obstacles to PPE use

22. Please indicate to what extent you agree with following statements related to implement or not to implement personal protection measures. *(all statements; single choice for each statement)*

I use personal protective equipment…	**Strongly agree**	**Agree**	**Disagree**
to protect my health	□	□	□
to protect the health of my family	□	□	□
because I already have health problems that make me more vulnerable	□	□	□
because I know of others who got infected from animals	□	□	□
because the veterinarian advised me to do so	□	□	□
because friends/colleagues convinced me that it is important	□	□	□
to prevent introducing diseases into the farm	□	□	□
because I know that the animals I work with are infected with diseases that could be transmitted to me	□	□	□
to improve the health and welfare of the animals	□	□	□
to improve the productivity of the animals	□	□	□
because it is recommended by regulations	□	□	□
I do not use personal protective equipment to prevent getting infections from the animals because…	**Strongly agree**	**Agree**	**Disagree**
it is expensive	□	□	□
I do not know how and when to use	□	□	□
it is difficult to use	□	□	□
it is time consuming	□	□	□
it is uncomfortable to use	□	□	□
it is too hot or too humid	□	□	□

J. Education and training

23. Does anyone discuss personal protective measures with you to avoid diseases transmitted from animals? *(single choice for the first level (yes/no); multiple choice for Yes)*

□ Yes, with…
- □ Official veterinarian at central level
- □ Official regional level/field veterinarian
- □ Private veterinarian
- □ Livestock associations
- □ Extension officers or paravets
- □ Public health personnel (doctors, nurses…)
- □ Other, please specify……

□ No

23.1. If no, what might be the reasons? Select all that apply. *(multiple choice)*

□ Veterinarians do not have enough time to discuss with farmers
□ Veterinarians are not interested in discussing it with farmers
□ Veterinarians do not think that personal protective measures will be implemented by the farmers
□ Veterinarians may believe that farmers have lack of awareness on disease risks
□ Veterinarians may believe that farmers already know
□ Veterinarians may believe that farmers do not want to invest in personal protective measures

24. Have you and your employees received training on diseases transmissible from animals to humans and/or how to prevent them? *(single choice)*

□ Yes □ No

25. Are you interested in learning more about diseases transmissible from animals to humans and/or how to prevent them? *(single choice)*

□ Yes □ No

25.1. If yes, what format would you prefer to learn more and by whom?

Format. Select all that apply *(multiple choice)*

□ Face-to-face □ Workshop □ Online □ Leaflets or brochures

□ Short videos □ TV

By whom. Select all that apply *(multiple choice)*

□ Official veterinarian at central level □ Official regional level/field veterinarian □ Private veterinarian □ Livestock associations

□ Extension officers or paravets □ Public health personnel (doctors, nurses…) □ Academicians

26. Is there anything else you would like to add? *(free text)*

……
……
……
……

Thank you for completing the survey!

Personal Biosecurity Questionnaire for Veterinarians

Introduction

This questionnaire is intended for veterinarians who work with farm animals, i.e. ruminants.

Please read aloud to the interviewee:

"This questionnaire will take approximately 20 minutes to complete. It covers demographic features, zoonoses, and understanding of personal biosecurity and its implementation on farms.

We would like to understand the practices that you implement on the farm to protect yourself from getting infected with zoonoses and why do you decide to implement them or not.

Most of the questions are single or multiple choice. Please answer all the questions.

Before we start, please confirm that you have read and signed the consent form.

Please note that your answers to this questionnaire will be anonymous."

Name/ID of the interviewer: Date of survey:

Location: Province: District: Village:

Language of the interview: *(single choice)*

□ Georgian □ Armenian □ Azerbaijani □ Other (please specify) ….

A. Socio-demographic features

1. What is your age? *(single choice)*

□ 18-30 □ 31-40 □ 41-50 □ ≥51

2. What is your gender? *(single choice)*

□ Male □ Female □ I do not want to answer

3. What is your marital status? *(single choice)*

☐ Married ☐ Not married ☐ I do not want to answer

4. How many years of experience do you have in the veterinary field? *(single choice)*

□ ≤10 □ 11-20 □ 21-30 □ 31-40 □ ≥41

5. What type(s) of livestock do you work with in the field? Select all that apply. *(multiple choice)*

□ Beef cattle □ Dairy cattle □ Sheep □ Goat

6. How many days per a week do you visit ruminant farms? *(single choice)*

□ 1-2 □ 3-4 □ Daily

7. Do you have any chronic diseases (diabetes, hypertension, chronic kidney disease, etc.) or immune disorder (rheumatoid arthritis, inflammatory bowel disease, multiple sclerosis, etc.)? *(single choice)*

□ Yes ☐ No □ I do not want to answer

If yes, please specify……

B. Zoonoses

8. What is your level of knowledge on zoonoses? *(single choice)*

□ High level □ Good level □ No knowledge

9. Which of the following diseases can be transmitted from animals to humans? Select all that apply. *(multiple choice)*

☐ Anthrax
☐ Brucellosis
☐ Ovine chlamydiosis

□ Ringworm
□ Animal tuberculosis
□ Ecthyma contagiosum (Orf)
□ Crimean Congo Haemorrhagic fever
□ Cryptosporidiosis
□ Leptospirosis
□ Cowpox
□ Echinococcosis
□ Q Fever
□ Other, please specify……..

10. Have you got infected with any zoonotic diseases in the last 10 years? *(single choice)*
□ Yes □ No

10.1. If yes, which disease(s)? Select all that apply. *(multiple choice)*
□ Anthrax
□ Brucellosis
□ Ovine chlamydiosis
□ Ringworm
□ Animal tuberculosis
□ Ecthyma contagiosum (Orf)
□ Crimean Congo haemorrhagic fever
□ Cryptosporidiosis
□ Leptospirosis
□ Cowpox
□ Echinococcosis
□ Q Fever
□ Other, please specify……

10.2. If yes, how many times in the last 10 years? *(single choice)*
□ 1 □ 2 □ 3 □ ≥4

C. Hygiene practices

11. How often do you wash your farm dedicated clothing? *(single choice)*
□ Daily □ Weekly □ Monthly □ Rarely □ Never

12. Where do you wash your farm dedicated clothing? *(single choice)*
□ At home □ At work place

13. When you wash your farm dedicated clothing, do you wash them separately from your other clothes? *(single choice)*
□ Yes □ No

D. Good general practices for preventing zoonoses

14. Please indicate how frequently do you apply following practices. *(all measures; single choice for each measure)*

Practices	Always	Sometimes	Never
Wash hands before contact with animals	□	□	□
Wash hands after contact with animals and their body fluids (e.g. blood, abortion materials, fetus, etc.)	□	□	□

If gloves are used, wash hands after contact with animals	☐	☐	☐
Wash hands after touching equipment contaminated with the body fluids of animals	☐	☐	☐
Wash hands after removing personal protective equipment	☐	☐	☐
Wash hands with bar soap	☐	☐	☐
Wash hands with liquid/foam soap	☐	☐	☐
Wash hands before eating, drinking and smoking	☐	☐	☐
Use alcohol-based disinfectants after washing hands	☐	☐	☐
Use disposable towels to dry hands	☐	☐	☐
Wash the wound site after getting a cut or scratch at the farm	☐	☐	☐
Cover cuts or abrasions on your skin with waterproof bandages	☐	☐	☐
Dispose sharps (e.g., needles, etc.) in sharps containers	☐	☐	☐
Remove the needle from the syringe by hand	☐	☐	☐
Remove the needle cap with mouth	☐	☐	☐

E. Implementing personal protective equipment

15. How often do you implement personal protective equipment during the following situations? *(all practices; single choice for each practice)*

Situations	Overalls	Gloves	Face masks	Protective glasses
Physical examination of healthy animals	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Physical examination of clinically sick animals	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Physical examination of an animal suspected of having an	☐ Always ☐ Sometimes ☐ Never If never why: • Useless	☐ Always ☐ Sometimes ☐ Never If never why: • Useless	☐ Always ☐ Sometimes ☐ Never If never why: • Useless	☐ Always ☐ Sometimes ☐ Never If never why: • Useless

infectious disease	• Not feasible • Too expensive • Time consuming • Other…..	• Not feasible • Too expensive • Time consuming • Other…..	• Not feasible • Too expensive • Time consuming • Other…..	• Not feasible • Too expensive • Time consuming • Other…..
Post-mortem examination	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Contact with blood, body substances, membranes, faeces or fluids of animals	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Surgery	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Vaccination, treatment and sampling	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..

Parturition	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Examination and disposal of aborted foetal membranes and stillbirths	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..
Disposal of carcasses	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..	☐ Always ☐ Sometimes ☐ Never If never why: • Useless • Not feasible • Too expensive • Time consuming • Other…..

F. Perceived risk of contracting zoonoses

16. What is the likelihood of exposure to zoonoses when the following situations are carried out on farms? *(all practices; single choice for each practice)*

Situations	Very likely	Likely	Unlikely
Physical examination of healthy animals	☐	☐	☐
Physical examination of clinically sick animals	☐	☐	☐
Physical examination of an animal suspected of having an infectious disease	☐	☐	☐
Post-mortem examination	☐	☐	☐
When contact with blood, body substances, membranes, faeces, or fluids of animals	☐	☐	☐
Surgery	☐	☐	☐
Vaccination, treatments, and sampling	☐	☐	☐
Parturition	☐	☐	☐
Examination and disposal of aborted foetal membranes and stillbirths	☐	☐	☐
Disposal of carcasses	☐	☐	☐

G. Motivators for and obstacles to PPE use

17. Please indicate to what extent you agree with following statements related to implement or not to implement personal protection measures. *(all statements; single choice for each statement)*

I implement personal protective equipment	**Strongly agree**	**Agree**	**Disagree**
to protect my health	□	□	□
to protect the health of my family/colleagues/friends/relatives	□	□	□
because I already have health problems that make me more vulnerable	□	□	□
because of a previous zoonotic disease experience	□	□	□
because my colleagues convinced me that it is important	□	□	□
to prevent introducing/spreading diseases into other farms	□	□	□
because I think implementing personal biosecurity is an individual responsibility	□	□	□
to improve the health and welfare of the animals	□	□	□
to improve the productivity of the animals	□	□	□
because it is recommended by regulations	□	□	□
because farmers expect me to implement personal biosecurity on their farms	□	□	□
because using PPE allows me to feel protected from diseases	□	□	□
because using PPE keeps my clothes clean	□	□	□
I do not implement personal protective equipment to prevent zoonoses because…	**Strongly agree**	**Agree**	**Disagree**
I think implementing personal biosecurity is a requirement of farmers	□	□	□
there are negative perceptions from farmers when I use PPE	□	□	□
my colleagues think I am being too cautious when implementing personal biosecurity	□	□	□
When PPE is provided by the farmer, it is often visibly dirty	□	□	□
When PPE is provided by the farmer, the size often does not fit me	□	□	□
it is expensive	□	□	□
I do not know how and when to use	□	□	□
it is difficult to use	□	□	□
it is time consuming	□	□	□
it is uncomfortable to use	□	□	□
it is too hot or too humid	□	□	□

H. Education and training

18. Do you advise the farmer(s)/employee(s) on personal biosecurity to protect themselves from zoonoses? *(single choice)*

□ Yes □ No

18.1. If no, what might be the reasons? Select all that apply. *(multiple choice)*

□ Farmers are not interested in discussing
□ Farmers do not want to invest in personal biosecurity
□ Farmers do not have the economic power to invest in personal biosecurity
□ Farmers do not have time to implement personal biosecurity
□ Farmers are not aware of infectious disease risks

19. Have you received training on zoonoses and/or how to prevent them? *(single choice)*

□ Yes □ No

20. Are you interested in learning more about zoonoses and/or how to prevent them? *(single choice)*

□ Yes □ No

20.1. If yes, what format would you prefer to learn more and by whom?

a. Format. Select all that apply *(multiple choice)*

□ Face-to-face □ Workshop □ Online □ Leaflets or brochures

□ Short videos □ TV

b. By whom. Select all that apply *(multiple choice)*

□ Official veterinarian at central level □ Official veterinarian at field level □ Private veterinarian □ Livestock associations

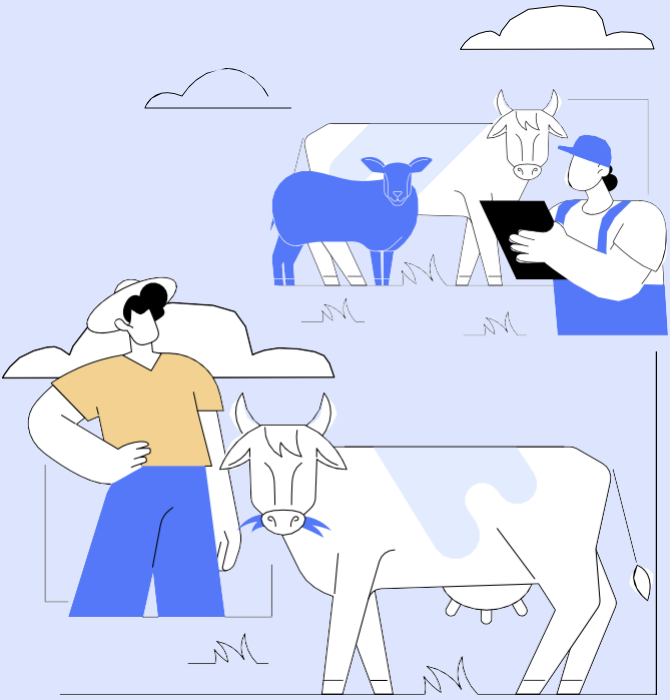
□ Extension officers or paravets □ Public health personnel (doctors, nurses…) □ Academics

21. Is there anything else you would like to add? *(free text)*

……
……
……
……

Thank you for completing the survey!

Food and Agriculture Organization of the United Nations



Protecting Yourself Against Animal Diseases

A Guide for Farmers

Many pathogens can spread between animals and humans (zoonoses), therefore ensuring the health of your animals will also help to protect you and your family from diseases.

This leaflet provides practical tips to keep you healthy while working with your animals.

Examples of high-risk activities

Disposing of aborted placentas and stillbirths

Handling sick and dead animals

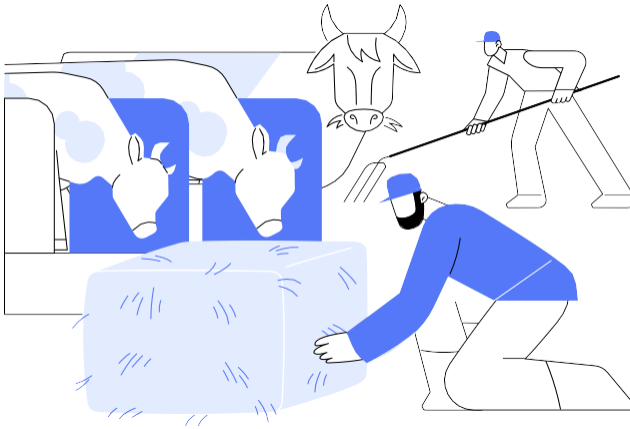
Assisting with parturition

Vaccinating, treating, and sampling animals

Cleaning stables

Hoof trimming and sheering

Keep your livestock healthy by preventing disease



Provide proper nutrition and a clean and comfortable environment: This supports animals' immune systems and reduces stress, making them less susceptible to illness

Practice good farm biosecurity: Buy new animals from reputable sources, limit visitors to your farm, and install and use barriers like fences

Follow vaccination and treatment protocols as recommended by your veterinarian

Seek veterinary advice if you detect any early signs of illness

Wash hands

This is the single most important measure you can take to prevent infection

1. After carrying out high-risk activities *(see Examples of high-risk activities)*
2. At the end of your workday
3. Before eating, drinking, and smoking

Remember:

- Gloves are not a substitute for hand washing
- Alcohol-based disinfectants can be used when hands are not visibly dirty
- Avoid touching your face, especially eyes, nose, and mouth, until you have washed your hands

How to wash your hands thoroughly with clean water and soap

Personal protective equipment (PPE)

PPE may include:

coveralls

boots/
boot covers

gloves

face masks

eye protection

- Use appropriate PPE when carrying out high-risk activities *(see Examples of high-risk activities)*
- Keep a set of clothes on the farm used exclusively for working with animals
- If possible, farm clothing should be washed at the farm. If brought home, keep it in a plastic bag and wash separately from other laundry
- Street clothes should be covered by protective outerwear/coveralls

Other general good practices

- Boil or pasteurize raw milk before consumption
- Wash fruits and vegetables thoroughly before eating or cooking
- Avoid home slaughter of livestock or do it under the supervision of a veterinarian (following national regulations)
- Avoid consuming raw or undercooked meat
- Do not eat meat from dead or sick animals
- Do not feed dogs and cats raw meat or viscera and prevent their access to the farm
- Remove and dispose of dead animals as soon as possible according to national regulations
- If wounded (e.g. a cut or scratch) while working with animals, wash with clean water and soap as soon as possible and cover it with a waterproof bandage
- Learn and use safe handling techniques to prevent being injured by animals
- Ensure a clean and safe water supply for both animal and human consumption
- Get vaccinated against zoonotic diseases, such as rabies, as recommended by your health department
- Seek medical advice if you develop symptoms of illness

Food and Agriculture Organization of the United Nations

Protecting Yourself Against Zoonoses

A Guide for Veterinarians

Veterinarians play a vital role in keeping animals healthy and preventing the spread of disease. This leaflet provides practical tips to help you stay healthy while working with animals and minimize the risk of carrying pathogens between farms. By following these recommendations, you can protect yourself, your staff, your clients, and your animals.

Examples of high-risk activities

Disposing of aborted placentas and stillbirths

Performing necropsies and handling dead animals

Examining clinically sick animals with potentially infectious diseases

Assisting with parturition

Vaccinating, treating, and sampling animals

Wash hands

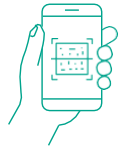
This is the single most important measure you can take to prevent infection

1. After carrying out high-risk activities *(see Examples of high-risk activities)*
2. At the end of your workday
3. Before eating, drinking, and smoking
4. After removing personal protective equipment (PPE)

Remember:

- Gloves are not a substitute for hand washing
- Alcohol-based disinfectants can be used when hands are not visibly dirty
- Avoid touching your face, especially eyes, nose, and mouth, until you have washed your hands

How to wash your hands thoroughly with clean water and soap



Personal protective equipment (PPE)

PPE may include:

coveralls

boots/
boot covers

gloves

face masks

eye protection

- Always wear protective outerwear (disposable or cleaned between farms) over your street clothes and shoes
- At the end of each working day, clothing dedicated to farm work should be kept in a plastic bag and washed separately from other laundry
- Use appropriate PPE when carrying out high-risk activities *(see Examples of high-risk activities)*

Other general good practices

- Boil or pasteurize raw milk before consumption
- Wash fruits and vegetables thoroughly before eating or cooking
- Avoid consuming raw or undercooked meat
- If wounded (e.g. a cut or scratch) while working with animals, wash with clean water and soap as soon as possible and cover it with a waterproof bandage
- Learn and use safe handling techniques to prevent being injured by animals
- Ensure a clean and safe water supply for both animal and human consumption
- Get vaccinated against zoonotic diseases, such as rabies, as recommended by your health department
- Seek medical advice if you develop symptoms of illness

SUPPLEMENTARY FILE 3

1. Farmers' results

Table 1a. Farm characteristics

	n (%) †		n ‡
Type of livestock		Type of production system	
Only-beef cattle	25 (5.8)	Nomadic	1
		Always kept indoor	17
		Extensive	6
		Semi-extensive	3
Only-dairy cattle	219 (50.6)	Always kept indoor	38
		Extensive	134
		Semi-extensive	50
Only-cattle of mix	72 (16.6)	Always kept indoor	12
		Extensive	10
		Semi-extensive	52
Only-sheep	44 (10.2)	Nomadic	16
		Always kept indoor	9
		Extensive	12
		Semi-extensive	10
Sheep & Goat	1 (0.2)	Nomadic	1
Different combinations of livestock	72 (16.6)	Various	
Total	433 (100)		

† Percentage of column

‡ The study observed that a single farm could simultaneously keep multiple types of livestock and maintain various production methods. The questions allowed multiple selections. The numbers indicate how many times each item was chosen.

Table 1b. Herd size of total holdings

mean	sd	IQR	0%	25%	50%	75%	100%	n
30.98614	154.7221	9	0	2	4	11	2000	433
Shapiro-Wilk normality test			W = 0.15847		p-value < 2.2e-16			

Table 2. Understanding of zoonoses and history of zoonotic disease experience among farmers

Do you think it is possible for you to get a disease from your animals?	Yes n (%) †	No n (%) †	I do not know n (%) †
	222 (51.3)	181 (41.8)	30 (6.9)
If yes, which diseases do you know can be transmitted from animals to humans?	n ‡		
• Brucellosis	182		
• Anthrax	117		
• CCHF	52		
• Ringworm	43		
• Animal tuberculosis	24		
• Cowpox	23		
• Q-fever	23		
• Echinococcosis	23		
• Ovine chlamydiosis	22		
• Orf	14		
• Other	8	do not know, hoof rot, foot and mouth disease (FMD), rabies	
• Cryptosporidiosis	6		
• Leptospirosis	4		
Which of the following diseases have been diagnosed on your farm /in your region?	n ‡		
• Brucellosis	173		
• Other	167	FMD, hoof rot, nabarevi, ketsi, I do not know, none of them, cattle skin disease	
• Anthrax	105		
• Q-fever	74		
• Ringworm	45		
• CCHF	23		
• Echinococcosis	14		
• Animal tuberculosis	10		
• Ovine chlamydiosis	9		
• Cowpox	7		
• Orf	5		
• Cryptosporidiosis	2		
• Leptospirosis	2		
Have you or anyone working in your farm got a disease from the animals in the last 10 years?	Yes n (%) †	No n (%) †	I do not know n (%) †
	24 (5.5)	401 (92.6)	8 (1.8)

† Percentage of row

‡ The questions allowed multiple selections. The numbers indicate how many times each item was chosen.

Table 3. Cleaning and disinfection measures in farmers' context

Measures	n	% †
How often do you clean/disinfect your farm?		
• Daily	210	48.5
• Every other week	37	8.5
• Monthly	35	8.1
• Once a week	105	24.2
• Once a year	46	10.6
How often do you clean/disinfect commonly used farm equipment?		
• After every use	179	41.3
• Daily	103	23.8
• Every other week	22	5.1
• Monthly	34	7.8
• Once a week	63	14.5
• Once a year	32	7.4
How often do you wash your farm dedicated clothing?		
• Daily	158	36.5
• Weekly	221	51
• Monthly	39	9
• Rarely	12	2.8
• Never	3	0.7
When you wash your farm dedicated clothing, do you wash them separately from your other clothes?		
• Yes	329	76
• No	104	24
Do you have…on your farm? (% of 'Yes')		
• a changing room	227	52.4
• a sink	320	73.9
• running water	316	73
• a bar of soap	357	82.4
• a liquid/foam soap dispenser	155	35.8
• alcohol-based disinfectants	176	40.6
• disposable towels	108	24.9
• hand dryer	82	18.9
Total	433	100.0

† Percentage of column

Table 4. Education and training regarding personal biosecurity in farmers' context

	Yes n (%) †	No n (%) †
Does anyone discuss personal protective measures with you to avoid diseases transmitted from animals?	226 (52.2)	207 (47.8)
If yes, who	n ‡	
• Official veterinarian at central level	18	
• Official regional level/field veterinarian	113	
• Private veterinarian	130	
• Livestock associations	13	
• Extension officers or paravets	2	
• Public health personnel (doctors, nurses…)	18	
If no, what might be the reasons	n ‡	
• Veterinarians do not have enough time to discuss with farmers	38	
• Veterinarians are not interested in discussing it with farmers	48	
• Veterinarians do not think that personal protective measures will be implemented by the farmers	61	
• Veterinarians may believe that farmers have lack of awareness on disease risks	42	
• Veterinarians may believe that farmers already know	112	
• Veterinarians may believe that farmers do not want to invest in personal protective measures	35	
Have you and your employees received training on diseases transmissible from animals to humans and/or how to prevent them?	Yes n (%) †	No n (%) †
	40 (9.2)	393 (90.8)
Are you interested in learning more about diseases transmissible from animals to humans and/or how to prevent them?	232 (53.6)	201 (46.4)
If yes, in which format	n ‡	
• Face to face	137	
• Workshop	31	
• Online	43	
• Leaflets or brochures	99	
• Short videos	27	
• TV	67	
By whom	n ‡	
• Official veterinarian at central level	90	
• Official regional level/field veterinarian	141	
• Private veterinarian	85	
• Extension officers or paravets	14	
• Public health personnel (doctors, nurses…)	64	

† Percentage of row

‡ The questions allowed multiple selections. The numbers indicate how many times each item was chosen.

Table 5. Summary of response variables used in comparative analyses in farmers' context

Measures †	mean	sd	IQR	min	Q1	Q2	Q3	max
Score_ good general practices for preventing zoonoses	25.80139	3.450349	3	12	25	28	28	28
Score_good general practices on farm regarding livestock care	7.482679	1.069484	1	0	7	8	8	8
PPE use_score healthy_animals	3.859122	2.372882	3	0	2	4	5	8
PPE use_score clinically _sick animals	5.256351	2.283468	4	0	4	6	8	8
PPE use_score animals_suspected_disease	5.575058	2.231825	4	0	4	6	8	8
PPE use_score dead_animals_dispose_carcasses	5.565820	2.304572	4	0	4	6	8	8
PPE use_score_parturition	5.085450	2.034334	2	0	4	5	6	8
PPE use_score dispose_membranes_stillbirths	5.210162	2.384302	4	0	4	6	8	8
PPE use_score cleaning_surfaces	4.796767	2.193274	4	0	3	4	7	8

† Shapiro-Wilk test of normality showed non-normally distributed data for each of the measure (p-value < 0.05)

Table 5a. Socio-demographic factors associated with the implementation level of personal biosecurity measures by farmers †

Factors / Preventive measures	Gender • Female • Male							Level of education • Primary school • Secondary school • High school • University degree • Postgraduate degree							Years of experience • ≤5 years • 6-10 years • 11-20 years • ≥20 years						
	Mean	sd	Min	q1	q2	q3	Mx	Mean	sd	Min	q1	q2	q3	Mx	Mean	sd	Min	q1	q2	q3	Mx
Good general practices for preventing zoonoses	26.4 25.1	2.7 4.1	13 12	26 23	28 27	28 28	28 28														
Good general practices on farm ensuring healthy livestock															7.6 7.7 7.3 7.4	0.8 0.8 1.2 1.1	4 4 0 2	8 8 7 7	8 8 8 8	8 8 8 8	8 8 8 8
PPE use when contacting with healthy animals	4.1 3.5	2.4 2.2	0 0	2 2	4 3	6 4	8 8	4.3 3.1 3.8 3.6 4.6	1.9 1.9 2.4 2.0 2.5	2 0 0 0 0	4 2 2 2 3	4 3 4 3 4	4 4 5.5 4 7.5	8 8 8 8 8	4.2 4.3 4.0 3.3	2.5 2.3 2.5 2.2	0 0 0 0	2.0 2.0 2.0 2.0	4 4 4 3	6.8 6 6 4	8 8 8 8
PPE use when contacting with clinically sick animals															5.3 5.7 5.2 4.9	2.5 2.0 2.3 2.2	0 0 0 0	3.3 4.0 4.0 3.0	6.0 6.0 6.0 5.0	8 8 8 6.2	8 8 8 8
PPE use during parturition															5.1 5.6 5.1 4.6	2.1 1.8 1.9 2.1	0 1 0 0	4 4 4 3	4.5 6.0 5.0 4.0	7.7 7.0 6.0 6.0	8 8 8 8
PPE use when cleaning surfaces/stables								5.2 3.8 4.7 5.3 5.6	1.8 1.8 2.2 2.0 2.0	4 0 0 2 2	4 3 3 4 4	4 4 4 5 5	6.2 4 7 8 8	8 8 8 8 8	4.8 5.3 4.9 4.3	2.2 2.1 2.1 2.2	0 2 0 0	3.2 4.0 4.0 3.0	4 5 4 4	6.7 8.0 7.0 6.0	8 8 8 8

† Results of comparative analyses with a p value of <0.05 were displayed.

Table 5b. Impact of farmers' understanding of zoonoses on the implementation level of personal biosecurity measures †

Factor / Preventive measures	Do you think it is possible for you to get a disease from your animals? • Yes • No • I do not know							Does anyone discuss PPE with you to avoid diseases transmitted from animals? • Yes • No						
	Mean	sd	Min	q1	q2	q3	Mx							
Good general practices for preventing zoonoses	25.4 26.3 25.3	3.5 3.3 3.5	12 14 16	24 26 24	27 28 27	28 28 28	28 28 28	26.3 25.3	2.9 3.9	12 12	25.2 24	27 27	28 28	28 28
Good general practices on farm ensuring healthy livestock	7.5 7.6 7.0	1.0 1.1 1.3	2 0 4	7 8 6.2	8 8 7	8 8 8	8 8 8	7.6 7.3	0.9 1.2	2 0	8 7	8 8	8 8	8 8
PPE use when contacting with healthy animals	3.4 4.6 2.3	2.0 2.6 2.0	0 0 0	2 3 2	3 4 2	4 8 2.7	8 8 8	4.0 3.7	2.1 2.6	2 0	2 2	4 3	5 6	8 8
PPE use when contacting with clinically sick animals	5.3 5.4 4.1	2.1 2.4 2.6	0 0 0	4 4 2	6 6 4	7 8 6	8 8 8	5.5 5.0	2.0 2.5	0 0	4 3	6 5	7 8	8 8
PPE use when contacting with animals suspected of having a disease	5.5 5.9 4.3	2.2 2.2 2.4	0 0 0	4 4 2.2	6 6 4	7 8 6	8 8 8							
PPE use when contacting with dead animals and disposal of carcasses	5.4 5.9 4.9	2.3 2.2 2.5	0 0 0	4 4 3	6 6 4	7 8 7.7	8 8 8							
PPE use during parturition	4.9 5.4 4.2	2.0 2.0 2.1	0 0 0	4 4 3	5 6 4	6 8 5.7	8 8 8	5.3 4.8	1.8 2.2	0 0	4 3.5	6 4	6 7	8 8
PPE use when disposing aborted foetal membranes and stillbirths	5.0 5.7 4.1	2.3 2.3 2.7	0 0 0	3 4 2	5 6 4	7 8 6	8 8 8							
PPE use when cleaning surfaces/stables	4.5 5.3 4.0	2.1 2.2 2.4	0 0 0	3 4 2	4 5 4	6 8 5.7	8 8 8							

† p value <0.05 with all displayed results

Table 5c. Impact of main perceived obstacles on the implementation level of personal biosecurity measures [†]

Obstacles / Preventive measures	PPE is uncomfortable to use • Disagree • Agree • Strongly agree							PPE is too hot/ humid to use • Disagree • Agree • Strongly agree						
	Mean	sd	Min	q1	q2	q3	Mx	Mean	sd	Min	q1	q2	q3	Mx
PPE use when contacting with clinically sick animals	5.6 5.3 4.3	2.3 2.2 2.2	0 0 0	4 4 3	6 6 4	8 8 6	8 8 8							
PPE use when contacting with animals suspected of having a disease	6.0 5.6 4.6	2.2 2.2 2.2	0 0 0	5 4 3	6 6 4	8 8 6	8 8 8	5.6 5.8 4.9	2.3 2.1 2.2	0 0 0	4 4 3	6 6 5	8 8 7	8 8 8
PPE use when contacting with dead animals and disposal of carcasses	5.9 5.6 4.6	2.2 2.3 2.4	0 0 0	4 4 3	6 6 4	8 8 6	8 8 8	5.5 5.8 5.0	2.4 2.1 2.4	0 0 0	4 4 3	6 6 6	8 8 7	8 8 8
PPE use during parturition	5.6 4.9 4.6	1.9 2.0 2.2	0 0 1	4 4 3	6 4 4	8 6 6	8 8 8	5.3 5.1 4.5	2.0 2.0 2.1	1 0 1	4 4 3	6 5 4	7 6 6	8 8 8
PPE use when disposing aborted foetal membranes and stillbirths	5.5 5.1 4.7	2.4 2.3 2.5	0 0 0	4 4 3	6 5 4	8 8 7	8 8 8							
PPE use when cleaning surfaces/stables	5.2 4.7 4.2	2.2 2.2 2.1	0 0 2	4 3 2	5 4 4	8 6 5	8 8 8	4.9 4.9 4.1	2.3 2.1 2.1	0 0 2	4 4 2	4 4 4	8 7 5	8 8 8

[†] p value <0.05 with all displayed results

2. Veterinarians' results

Table 6. Knowledge on zoonoses and history of zoonotic disease experience among veterinarians

		n	%
Self-reported level of knowledge on zoonoses	No knowledge	0	0
	Good knowledge	34	29.8
	High knowledge	80	70.2
Which of the following diseases are zoonotic? †		n ‡	
	Brucellosis	67	
	Anthrax	51	
	CCHF	35	
	Animal tbc	26	
	Ringworm	26	
	Echinococcosis	22	
	Cowpox	23	
	Q fever	26	
	Orf	24	
	Ovine chlamydiosis	25	
	Other §	12	
	Leptospirosis	14	
	Cryptosporidiosis	11	
		n	%
History of zoonoses	Yes	7	6.1
	No	107	93.9
If yes, which diseases			
	Anthrax	2	
	Brucellosis	2	
	CCHF	2	
	Ringworm	1	
	Other	1	
If yes, how many times			
	Anthrax	2	
	Brucellosis	3	
	CCHF	≥ 4	
	Ringworm	1	
	Other	1	

† The questions allowed multiple selections. Only 4 veterinarians indicated all listed diseases as zoonotic.
‡ Number of times the corresponding item was mentioned. Although respondents were allowed to select more than one options, it was observed that online questionnaire respondents indicated only one option for each of the question.
§ Trichinellosis, foot and mouth disease, rabies, piroplasmosis, gangraena emphysematosa, demodicosis were mentioned.

Table 7. Cleaning and disinfection measures in veterinarians' context

Measures	n	%
How often do you wash your farm dedicated clothing?		
• Daily	85	74.6
• Weekly	21	18.4
• Monthly	1	0.9
• Rarely	1	0.9
• Never	6	5.3
Where do you wash your farm dedicated clothing?		
• At home	95	83.3
• At work place	19	16.7
Do you wash your farm-dedicating clothing separately from your other clothes?		
• Yes	95	83.3
• No	19	16.7
Total	114	100

Table 8. Education and training regarding personal biosecurity in veterinarians' context

	Yes n (%)	No n (%)
Do you advise the farmer(s)/employee(s) on personal biosecurity to protect themselves from zoonoses?	114 (100)	-
Have you received training on zoonoses and/or how to prevent them?	99 (86.8)	15 (13.2)
Are you interested in learning more about zoonoses and/or how to prevent them?	107 (93.9)	7 (6.1)
If yes, in which format	n (field+official) †	
• Face to face	44+23	67
• Workshop	26+19	45
• Online	18+2	20
• Leaflets or brochures	24+1	25
• Short videos	9+0	9
• TV	10+0	10
By whom	n (field+official) †	
• Official veterinarian at central level	45+29	74
• Official veterinarian at field level	32+5	37
• Private veterinarian	13+0	13
• Livestock associations	26+3	29
• Extension officers or paravets	6+2	8
• Public health personnel (doctors, nurses…)	18+1	19
• Academicians	11+5	16

† Number of times the corresponding item was mentioned. Although respondents were allowed to select more than one options, it was observed that online questionnaire respondents indicated only one option for each of the question.

Table 9. Summary of response variables used in comparative analyses in veterinarians' context

Measures †	mean	sd	IQR	min	Q1	Q2	Q3	max
Score_ good general practices for preventing zoonoses	26.73684	1.914327	2	20	26	26	28	30
PPE use_score_physical examination of healthy animals	5.622807	2.432779	4	0	4	6	8	8
PPE use_score_ physical examination of sick animals	6.552632	1.805067	2	2	6	7.5	8	8
PPE use_score_ physical examination of an animals suspected infectious disease	6.877193	1.714799	2	0	6	8	8	8
PPE use_score_ post-mortem examination	6.903509	1.950581	2	0	6	8	8	8
PPE use_score_ contact with blood, body fluids of animals	7.04386	1.726372	0	6.25	8	8	8	8
PPE use_score_surgery	6.263158	2.784447	2	0	6	8	8	8
PPE use_score_vaccination, treatment, sampling	6.482456	1.978792	2	0	6	8	8	8
PPE use_score_parturition	5.921053	2.78156	4	0	4	8	8	8
PPE use_score_ disposal of aborted membranes /stillbirths	6.631579	2.324411	2	0	6	8	8	8
PPE use_score_ disposal of carcasses	6.894737	2.100857	2	0	6	8	8	8

† Shapiro-Wilk test of normality showed non-normally distributed data for each of the measure (p-value < 0.05)

Table 10. Factors associated with the implementation level of personal biosecurity measures by veterinarians †

Factors / Preventive measures	Weekly working days • 1-2 days • 3-4 days • Daily							Level of knowledge on zoonoses • Good knowledge • High knowledge							Veterinary profession • Field veterinarians • Official veterinarians						
	Mean	sd	Min	q1	q2	q3	Mx	Mean	sd	Min	q1	q2	q3	Mx	Mean	sd	Min	q1	q2	q3	Mx
PPE use during physical examination of healthy animals	4.7 6.1 7.8	2.4 2.4 1.9	0 0 2	3 5 6	5 7 8	6.5 8 8	8 8 8	4.8 5.9	2.7 2.2	0 0	3 4	5 6	7.7 8	8 8	6.5 4.3	1.9 2.5	0 0	5 2	8 4	8 6	8 8
PPE use during physical examination of clinically sick animals	6.0 7.1 6.9	1.8 1.6 1.8	2 2 2	4.5 6.5 6.7	6 8 8	8 8 8	8 8 8	5.9 6.8	1.9 1.7	2 2	4 6	6 8	7.7 8	8 8	7.0 5.8	1.5 2.0	2 2	6 4	8 6	8 8	8 8
PPE use during physical examination of an animals suspected infectious disease								6.4 7.1	1.9 1.6	2 0	6 6	6.5 8	8 8	8 8	7.4 6.1	1.2 2.1	2 0	7 6	8 6	8 8	8 8
PPE use when contact with blood, body fluids of animals															7.4 6.5	1.5 2.0	0 2	8 5	8 8	8 8	8 8
PPE use during surgery	5.6 6.7 7.2	3.0 2.7 2.0	0 0 0	5.5 7 7.7	6 8 8	8 8 8	8 8 8	5.4 6.6	3.1 2.6	0 0	3.2 6	6.5 8	8 8	8 8	7.3 4.6	1.4 3.5	0 0	7 0	8 6	8 8	8 8
PPE use during vaccination, treatments, and sampling	6.0 7.2 6.5	2.0 1.5 2.2	0 2 0	4 7 6	6 8 8	8 8 8	8 8 8	5.7 6.8	2.2 1.8	0 0	4 6	6 8	8 8	8 8	7.1 5.5	1.6 2.1	0 0	7 4	8 6	8 8	8 8
PPE use during parturition	5.2 6.4 6.7	2.9 2.7 2.3	0 0 0	4 6.5 6	6 8 8	8 8 8	8 8 8	4.8 6.4	3.3 2.4	0 0	2 5.7	5 8	8 8	8 8	7.1 4.1	1.6 3.2	0 0	7 0	8 4	8 8	8 8

PPE use during examination and disposal of aborted foetal membranes and stillbirths9	5.9 7.3 7.2	2.8 1.2 1.9	0 4 0	5 7 8	7 8 8	8 8 8	8 8 8										
										7.1 5.9	1.7 2.9	0 0	7 4	8 8	8 8	8 8

† Results of comparative analyses with a p value of <0.05 were displayed.

Universitat Autònoma de Barcelona

The research work, entitled: “Personal Biosecurity Measures Followed by Ruminant Veterinarians and Farmers in the Country of Georgia” has been carried out by Saliha ŞAHİN and is presented as a requirement to obtain the degree of Official Master in Zoonoses and One Health, under the direction of Alberto Oscar Allepuz PALAU.

Cerdanyola del Vallás, on the 8th of March 2025.

For the record, the following sign this document,

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